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Benefits of Water Quality Enhancement

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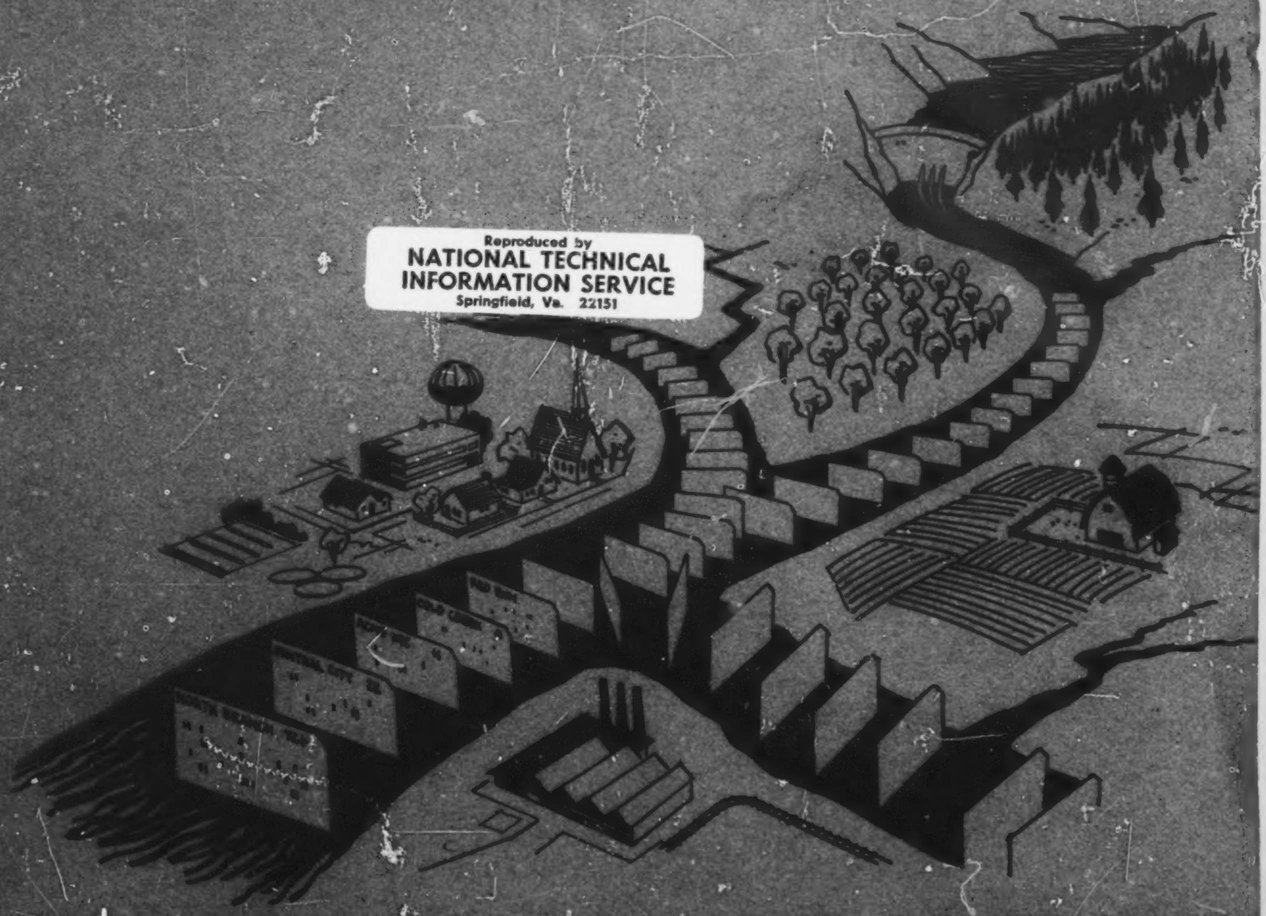

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27 Abstract
This research was carried out over a three year period ending September 1, 1970. During the first two years two related subject areas were studied, The Development of a Pollution Index for Benefit Analysis and Measurements of the Total Dollar Benefit of Water Pollution Control. During the final year the Benefits of Water Quality Enhancement were studied further in order to implement pollution abatement at a local level of government. These three separate but related aspects of the overall project are included in this Final Report and Described as Part A, B and C.

Part A contains a discussion of the past practices and recent trends in water pollution control as it relates to water quality.

Part B describes the dollar benefit of a lake or stream at a given water quality is determined by listing all uses which both affect and are affected by water quality, by valuing each use individually, and by summing the resultant values.

In Part C a study was undertaken of a methodology for water pollution abatement administration at the local or regional level, using Onondaga Lake, N. Y. as an example.

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Benefits of Water Quality Enhancement

by

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for the

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ABSTRACT

This research was carried out over a three year period ending September 1, 1970. During the first two years two related subject areas were studied, *The Development of a Pollution Index for Benefit Analysis* and *Measurements of the Total Dollar Benefit of Water Pollution Control*. During the final year the *Benefits of Water Quality Enhancement* were studied further in order to implement pollution abatement at a local level of government. These three separate but related aspects of the overall project are included in this Final Report and described as Part A, B and C.

PART A contains a discussion of the past practices and recent trends in water pollution control as it relates to water quality. Special consideration is given to the difficulties with both single item and multiple item water quality criteria. A new *Pollution Index* is proposed to measure the relative pollution when multiple items of water quality are considered. The Pollution Index is specific for one of three classifications of water use; human contact, indirect contact, and remote contact. An *Overall Pollution Index* is also proposed as a weighted average of the three Pollution Indices; the weight of each being related to the relative type use of the watercourse.

In Part B the dollar benefit of a lake or stream at a given water quality is determined by listing all uses which both affect and are affected by water quality, by valuing each use individually, and by summing the resultant values. The values of beneficial uses are measured by the willingness to pay of the user or an evaluation of benefits derived from avoiding payment. The value of these uses is estimated by taking surveys of the users at the lake or stream. The annual demand and unit benefit are determined for each use and the product gives total annual benefits for that use. Total annual dollar benefit at a given water quality is the sum of these benefits for each use. Annual social benefit is measured at existing water quality and estimated at an improved water quality. This estimate is made by comparison of user demand at lakes and streams with existing high water quality or by projection of latent user demand. The difference in the benefits at two different water qualities gives net annual social benefit which is the estimated annual increase or decrease in value of a lake or stream which a corresponding increase or decrease in water quality. Onondaga Lake at Syracuse, New York is used as an example. An economic analysis using this procedure produces a net social benefit of 4.4 million dollars annually if Onondaga Lake water quality were improved to support swimming, sport fishing, municipal water supply and higher-valued shoreline land uses.

In Part C a study was undertaken of a methodology for water pollution abatement administration at the local or regional level, using Onondaga Lake, N. Y. as an example. Previous investigations regarding the sale of water pollution assimilative capacity, dollar benefits from pollution abatement, and pollution index were related in such a manner so as to establish a discharge price for polluting materials based on an increasing price with diminishing resources. The amounts to be sold are established by the governing board. Each discharger is given the opportunity to purchase some discharge privileges, but must at some time make the decision to remove contaminants rather than discharge them. Prices are established to make the purchase of discharge privileges prohibitive at the point where water quality becomes questionable for a stated objective.

The investigation included a critical review of current abatement procedures as well as the results of an attempt to have a regional river basin board utilize the methodology on a trial basis. Although the basin board did not actually utilize the methodology, for reasons explained in the report, the meetings with the board did establish the desirability of resource sales as a means of pollution abatement.

The overall report was submitted in fulfillment of Grant No. WD-01089-01 under the sponsorship of the Federal Water Pollution Control Administration, subsequently Grant No. 16110 DAJ under the Federal Water Quality Administration, and presently under the Environmental Protection Agency.

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PART A - POLLUTION INDEX FOR BENEFIT ANALYSIS

Developed by

Nelson L. Nemerow and Hisashi Sumitomo

SECTION I

CONCLUSIONS

1. A pollution index can be developed for specific water uses when multiple items of water quality are considered.
2. The pollution index is specific for one of three classifications of water use; human contact, indirect contact, and remote contact.
3. An overall pollution index can be developed as a weighted average of the three specific indices, the weight of each being related to the relative type use of the watercourse.

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SECTION II

RECOMMENDATIONS

In this paper, fundamental water quality expression methods are discussed for pollution control problems. Because of the recent increasing tendency to control pollution in a regional unit, suitable quality expression methods for pollution should be developed. In addition, benefits of pollution control are becoming increasingly important in cost analysis. Multiple items of water qualities are required for the benefit analysis of pollution. Therefore, in this paper, a Pollution Index method is proposed to cope with the regional benefit analysis of pollution. This type of simple overall expression of water quality may be useful for administrative purposes and for communication with the public regarding pollution control.

The relative expressions of the multiple items of water qualities with the respective permissible levels for a use are proposed in this paper as the principal idea of the Index method. A practical method for computing the Index is also proposed for future development of this kind of concept for expressing quality of pollution. However, the procedures outlined are not proposed as a final product of this concept, but rather as a starting point from which refinements can be added through experiences.

The authors recognize that many assumptions and prejudgements have been made in developing the technique of computing a Pollution Index. The authors also recognize the limitations of the use of the Pollution Index and that other methods may be used to arrive at other measures of the degree of contamination. This is but one approach toward integrating the level of contamination of various ingredients into a single number describing the overall degree of pollution.

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SECTION III

INTRODUCTION

The desire to solve water pollution control problems on a nationwide scale resulted in passage of the Water Quality Act of 1965. The establishment of Water Quality Standards for Interstate water is the most important part of the Act influencing the activities of pollution control. Measurement and expression of a polluted water quality are important factors in controlling pollution. At present, water quality is usually expressed by several items such as BOD (Biochemical Oxygen Demand), DO (Dissolved Oxygen), Coliform bacteria count, and so on. However, 'pollution' and 'a polluted water' are relative terms, and expressions to describe them have been arbitrarily chosen in each instance. These expressions chosen to differentiate a polluted water from a clean water have been mainly based on the characteristics of the water uses. As an example, the item of fecal coliform count is selected for a regional recreational use to express one form of a pollution. On the other hand, the items of pH, hardness, suspended solids, copper, iron and manganese concentrations have been selected for a textile industry. Even though agreement may be reached on the proper expression of pollution, persons may not agree on the critical values of those expressions.

More recently, and especially in regional systems, benefits of pollution control and damages of pollution are being considered. Regional rather than local or separate individual control systems has great merit. A major characteristic of the regional system is that a region is often composed of many different kinds of waste discharges and water uses. Therefore, the most basic and decisive problem is how to quantify pollution by an all-inclusive common measurement of all contaminants for the society affected by it. This is made difficult because of the many existing different quantification methods of pollution as previously mentioned. Up to now, in regional cases, one representative item such as BOD or DO has often been selected as an overall common expression of pollution neglecting the effects of the other items of water qualities, or assuming that those effects may be substituted by the representative item. For example, in New York State the only water quality which has specific minimum levels is dissolved oxygen. It is also common to use multiple items of water qualities to maintain a minimum water quality level. These single item and multiple item common expressions of pollution are not always satisfactory. A single item cannot always serve as a substitute for other important items especially in a large regional problem in which many kinds of water uses coexist; and also in the multiple item method, the quantified values are often expressed as discrete values rather than useful moving plots of pollution characteristics. The mutual relations of those multiple items of water quality such as pH, BOD, and DO are also unclear at this stage. Therefore it is most urgent that a simple, reasonable, and useful method be developed for expressing

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quality of polluted water. The major purpose of this paper is the development of one such common quality expression for relative states of pollution of a watercourse (Nemerow, 1967).

SECTION IV

WATER QUALITY EXPRESSIONS IN WATER POLLUTION CONTROL PROBLEMS

Pollution control problems may be classified quite generally into two groups based on the purpose of the problem itself. In one group, pollution control is concerned with a single item of water quality, and in the other group, multiple items of water qualities are used. For instance, a specific control problem of either iron, color, or temperature in water supply is an example of the first group. On the other hand, a problem of the determination whether a water is suitable for swimming requires the use of multiple items such as coliform bacteria, pH, color, and turbidity. Most of the problems, strictly speaking, are classified into the second group in which it is difficult to express an absolute measure of pollution. But, some problems in this group can often be transfered into the first group in practice. One representative item is often selected from the multiple items. Stream quality description by DO sag curve and the decision of BOD removal efficiency at sewage treatment plants are typical examples of the transfer. In the above case, the concentration of total biodegradable organic matter is used as an index of pollution, neglecting the other items of qualities, and the purpose of sewage treatment is practically defined as a removal of the organic matter expressed as BOD.

However, when considering a specific water use, such simplification as the above example is not realistic, since water quality must satisfy other contaminant criteria simultaneously. When water is used for swimming and cooling, for example, multiple items such as coliform bacteria, temperature, pH, and so on should be used rather than a general expression of pollution such as BOD. Single item quality control (such as BOD) can only be used when the receiving water is not being used for a specific purpose. In certain cases where data are incomplete or water use is not highly specialized, single item quality control may still be useful. For these cases, the values expressed for water quality can be employed as a measure of pollution without any special problems. In the second group, a direct expression of all the multiple items concerned could be employed as a measure of pollution, if discrete values can measure pollution for the existing expression of a minimum quality level, and if each item is employed quite independently among multiple items themselves. Quality standards for classified waters in New York State such as a range between 6.5 to 8.5 in pH and 4.0 to 5.0 in DO are examples of discrete and independent expressions of pollution using multiple items. It should be emphasized here that pollution can be quantified quite reasonably by the existing quality expression methods in many cases as shown in the above. In these instances, additional discussions of a general expression method of pollution are not required.

Maximum treatment efficiency and/or minimum treatment cost have been mainly used to control pollution. Pollution control problems have been considered as problems in the first group, most of which are transferred from the second group. Therefore, one of the major items such as BOD, COD, or DO has been reasonably employed for those cases as a general expression of pollution. More recently, in regional problems, uses of the water body into which the treated wastes are discharged are usually taken into account to arrive at an optimum control method changing from the minimization of the treatment costs to some sort of maximization of the total benefits of water uses in an entire region including the treatment costs as negative benefits. The authors believe that in the discussion of the many kinds of regional uses of a receiving water, the use of multiple item expression of pollution is both useful and necessary.

A brief procedure to select the appropriate water quality expression method in water pollution control problems is suggested as follows:

1. The major purpose of the pollution control and the definition of the pollution should be clarified, and the problem should be classified into one of two groups, based on single or multiple water quality items concerned. (Even after the classification, the possible transfer from the multiple item group to the single item group must be considered.)

2. The scale of the control problem should be checked to determine whether it is local or regional.

3. Determine whether the pollution control objective involves the uses of the receiving water or is only concerned with the waste treatment.

The proper quality expression method can now be determined for each control problem by using Table - 1, from which the water pollution control problems can be generally defined as follows:

1. For local and individual problems, the existing methods of single item or multiple discrete items are applicable.

2. For regional problems, the quality expressions suggested are as follows:

   a) The existing expression using a representative item such as BOD or DO is advantageous, if only treatments are discussed for pollution control without consideration of the individual uses of the water body. (e.g. Cost analysis of regional waste treatment.)

   b) A new expression using multiple items should be developed, if the treatments are discussed, considering the effects of the treatments for the individual uses of the receiving water. (e.g. Benefit analysis of a regional waste treatment.)

c) The existing expression by multiple items is useful for a discrete quality expression of a pollution. (e.g. Stream quality standards expressed using multiple items.)

Table-1. Quality Expression Methods of a Pollution for Pollution Control Problems

Number of items concerned with the problem / Size of the problem / Purpose of the problem	Single		Multiple	
	Local	Regional	Local	Regional
Discussions of discharges (Removal efficiency and cost of waste treatment) e.g. Cost and efficiency analysis	* Trad. ex: (BOD removal, etc.)	* Trad. ex: (DO sag curve, etc.)	* Trad. (Ind)	* Trad. (Ind) or * Index
Discussions of discharges and uses of the receiving water. (Effects and damages of waste treatment) e.g. Benefit Analysis	* Trad. ex: (Toxic ion removal, Temperature increase, etc.)	* Trad. ex: (Spread of disease germ, toxic ion removal, etc.)	* Trad. (Ind.)	* Trad. (Disc.) and * Index

*Note: Trad. = Traditional expression by the existing water quality expression method.
Trad. (Ind.) = Independent expression of each item using the existing water quality expression method.
Trad. (Disc.) = Discrete value expression by traditional expression such as stream standards.
Index = A new continuous quantification method of a pollution considering multiple items of water qualities.

SECTION V

A PROPOSAL OF POLLUTION INDEX

A new quality expression method of pollution is required especially for regional benefit analysis of pollution control, as mentioned in the previous section. On a regional basis, all effects of a pollutant on the uses should be taken into account at the same time to evaluate total damages of the pollution. In the rest of this section a common and overall measuring unit of pollution will be discussed, considering overall effects of the multiple items of pollutants for specific uses.

An expression of pollution quality will be developed by a single value for each major classified water use, which is arbitrarily referred to as 'PI'. An overall expression of pollution quality for all uses will be derived from these Index values. Certain precision is sacrificed in developing an Overall Index value. But, such an overall quality expression of pollution is expected to be useful for many practical purposes. For example, it may offer means for measuring pollution to be used for administrative purpose and as communication with the public (Horton, 1965).

Basic Consideration for the Index

The primal problem in developing the Index is how to integrate the independent multiple items of pollutants in a water into a common expression. There is often little correlation between the significance as well as the dimension of each pollutant: For instance, 1,000 (MPN/100 ml) in coliform count, 6 (mg/l) in DO, and 80 (°F) in temperature. Each value may be compared only with the same item of quality. When those values are related to some kind of standard values of the respective items such as coliform number of 500/100ml, DO of 5 mg/l, and temperature of 50°F, the relative value can be expressed as 2.0 (1000/500 = 2.0), 1.2 (6/5 - 1.2), and 1.6 (80/50 = 1.6) respectively, as non-dimensional relative values.

It is possible to derive a meaningful, comparable and relative value, if reasonable standard values are chosen. If these standard values are the permissible quality levels, the PI can be defined as a truly relative term. The permissible pollutant level at a location of a water use is recommended here as the standard value for the Index development. An Index for a major specific water use will be developed first, and then the overall Index, which is a common measure of a pollution for all uses, will be discussed.

When the multiple items of water qualities are expressed as C_i's and the permissible levels of the respective items for a use are expressed as L_{ij}'s, the Pollution Index for the use, j, PI may be expressed as a function of the relative values, (C_i/L_{ij})'s. Here, i is the number of the i-th item of water quality and j is the number of the j-th water use.

$$PI = \text{A function of } ((C_i/L_{ij})\text{'s}) \text{ ....(1)}$$

$$\text{or} = f \; (C_1/L_{1j},\ C_2/_{2j},\ C_3/L_{3j},\ \ldots\ C_1/L_{1j})$$

$$(i\ 1, 2, 3, \ldots.\ i, \ldots\ I.$$

$$j\ 1, 2, 3, \ldots.\ j, \ldots\ J.)$$

This approach is similar to that used in describing toxicity of multiple items of toxic materials. When several toxic materials (T_1, T_2, T_3, ...) coexist in a water, it is suggested that the total toxicity may be evaluated by the next relation, applying the respective permissible levels (TL_1), (TL_2), (TL_3),..).

$$\text{Total toxicity} = T_1/(TL_1) + T_2/(TL_2) + T_3/(TL_3) + \ldots\ \ldots \text{ (2)}$$

Development of the Pollution Index

The Index may be expressed by the relative value (C_i/L_{ij})'s as shown in the relation (1). Each value of (C_i/L_{ij}) shows the relative pollution contributed by the single item. A value of 1.0 is the critical value for each (C_i/L_{ij}). Values greater than 1.0 signify a critical condition under which a proper treatment is necessary for the water use. The major problem here is visualizing how to get an Index value from the multiple relative values. Theoretically speaking, there is no absolute solution among the numerous possible methods. However, we propose a reasonable method for an overall expression of pollution. The arithmetic average value of all the calculated (C_i/L_{ij}) values may be recommended as one of the important parameters for the PI_j. This parameter both considers all contaminants and is influenced by the extreme values as well.

For example, when the quality of a water is expressed as BOD (C_1) as 10mg/l, coliform bacteria (C_2) as 1,300/100ml, and hardness (C_3) as 80 mg/l, and their permissible levels for a use j are given as BOD (L_{1j}) as 20mg/l, coliform (L_{2j}) as 1,000/100ml, and hardness (L_{3j}) as 100mg/l, then the (C_i/L_{ij}) values are expressed as follows: $(C_1/L_{1j}) = 0.5$, $(C_2,/_{2j}) = 1.3$, and $(C_3/L_{3j}) = 0.8$. The average value of the above three values is about 0.9 which may generally indicate that the water is just under the critical condition for the use j with no treatment of the water. However, the average value may not satisfactorily measure pollution, because the necessity of water treatment for a use is often determined by the maximum value of the (C_i/L_{ij}) values rather than the average value. Even if the mean value is very small, say under 1.0, the water cannot be used for use j without treatment, if one of (C_i/L_{ij}) values is over 1.0. As shown in the above example in which the mean value (0.9) is under 1.0, the water should be treated for the use, because one item, coliform bacteria, is over the permissible level, $(C_2/L_{2j} = 1.3)$. Therefore, the maximum of the (C_i/L_{ij}) values is proposed as another significant factor to be included in computation of PI_j, in addition to the mean value. The index may be expressed using the maximum and mean values of the (C_i/L_{ij}) values, as shown in the next relation.

$PI = f$ (max. of (C_i/L_{ij})'s and mean of (C_i/L_{ij})'s .... (3)
The relation (3) shows that the index PI, is expressed by the maximum and mean values of (C_i/L_{ij}) values, althouth the relation among those three contaminants is still unknown. One expression of the relations (3), when the abcissa is the maximum (C_i/L_{ij}) and the ordinate is the mean (C_i/L_{ij}), shows PI_j value as a point somewhere in the space between the two axes as shown in Fig. - 1. It may be generally agreed that the larger the values of maximum (C_i/L_{ij}) and/or mean (C_i/L_{ij}), the more the water is polluted. Therefore the length of the line from the origin to the Point PI_j in Fig. - 1 may be proposed as a significant factor to express pollution. Another factor (θ) in Fig. - 1 is determined by the ratio of both values of the maximum and mean (C_i/L_{ij})'s. But, it is difficult from a practical standpoint to discuss the significance of the ratio of the maximum and mean values of (C_i/L_{ij})'s or to determine which is relatively more important in regard to pollution. Many existing data plotted according to the above graphic considerations are distributed within a limited angle as seen in Fig. - 2. It is proposed that the general quality expression of pollution for use j is related to the length of a line between the origin and each point. The length is determined by the two values of the maximum and mean of (C_i/L_{ij}) values in Fig. - 1. In our computation of a pollution index, we propose to

neglect the effect of the of the angle (ϕ). The PI for use j, PI_j, is measured by the lengths of the radii of the concentric circles as shown in Fig. - 3. Therefore, the relation (3) is expressed as shown in Fig. - 3 as follows:

$$PI_j = m \quad \max. (C_i/L_{ij})^2 + \text{mean}. (C_i/L_{ij})^2 \; ..... \; (4)$$

Here, m = the proportionality constant.

A critical condition to determine the coefficient m is recommended as follows:

$$PI_j = 1.0, \text{ when } \max. (C_i/L_{ij}) = 1.0 \qquad \text{and mean}. (C_i/L_{ij}) = 1.0 \; .... (5)$$

This means that the Index for use j is expressed as 1.0 when all items of water qualities are just equal to their respective permissible levels for the use. The relation (4) is as follows under conditions of (5).

$$1.0 = m \sqrt{1^2 + 1^2} \quad , \quad \therefore \quad m + 1/\sqrt{2}$$

Therefore, PI_j is consequently proposed as follows, and the relation among those three is expressed graphically as shown in Fig. - 3.

Overall Pollution Index

The Index in equation (6) is proposed only for a particular use j. However, with some modification, it may be employed for some sort of grouped uses depending upon what kind of permissible levels are employed as L_{ij}'s. If the L_{ij}'s are determined from the general permissible levels for swimming, boating, sport fishing, and hiking, as an example, the Index PI_j, may be defined as the Pollution Index for outdoor recreation use. All existing water uses in the region should be taken into consideration in regional benefit analyses of pollution control problems. An overall Pollution Index, $\overline{PI}$, can be used for such problems. If an overall permissible level for all uses in a region can be determined, the overall Pollution Index could be easily determined by equation (6), employing the overall permissible level for L_{ij}'s, (j = all uses.) However, such permissible levels have not yet been developed. The overall Index, $\overline{PI}$, is recommended for general use as a kind of the mean value of the calculated respective PI_j's for all uses in the region.

When pollution is quantified for each use by the PI_j's such as, for example, 5.0 for drinking, 1.0 for swimming, and 0.9 for an industrial use, these values will indicate a more general evaluation of the pollution for all uses, if the relative importances of those water uses are quantified in the region. If the swimming and the industrial uses are negligible or not so important in the region, the overall evaluation of pollution may depend mainly upon drinking use. In this case the

$$PI_j = \sqrt{1/2}\,\sqrt{\max.(C_i/L_{ij})^2 + \text{mean}.(C_i/L_{ij})^2}$$

$$\text{or} = \sqrt{\frac{\max.(C_i/L_{ij})^2 + \text{mean}.(C_i/L_{ij})^2}{2}} \quad \ldots. (6)$$

Fig.-1.

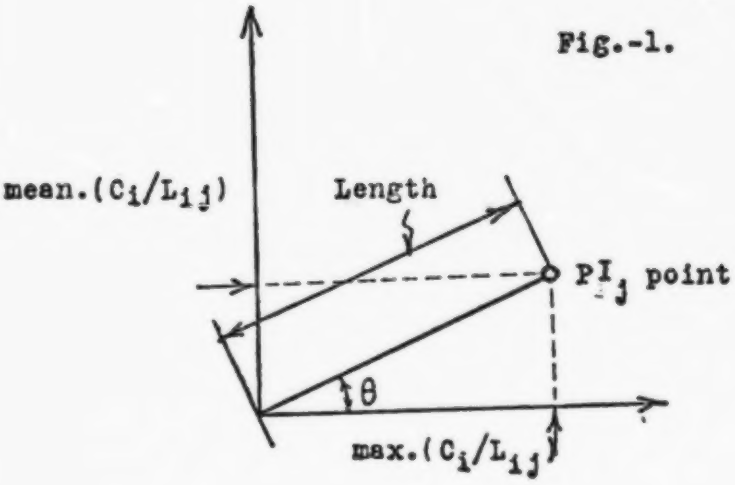

mean.(C_i/L_{ij})
Length
PI_j point
θ
max.(C_i/L_{ij})

Fig.-3.

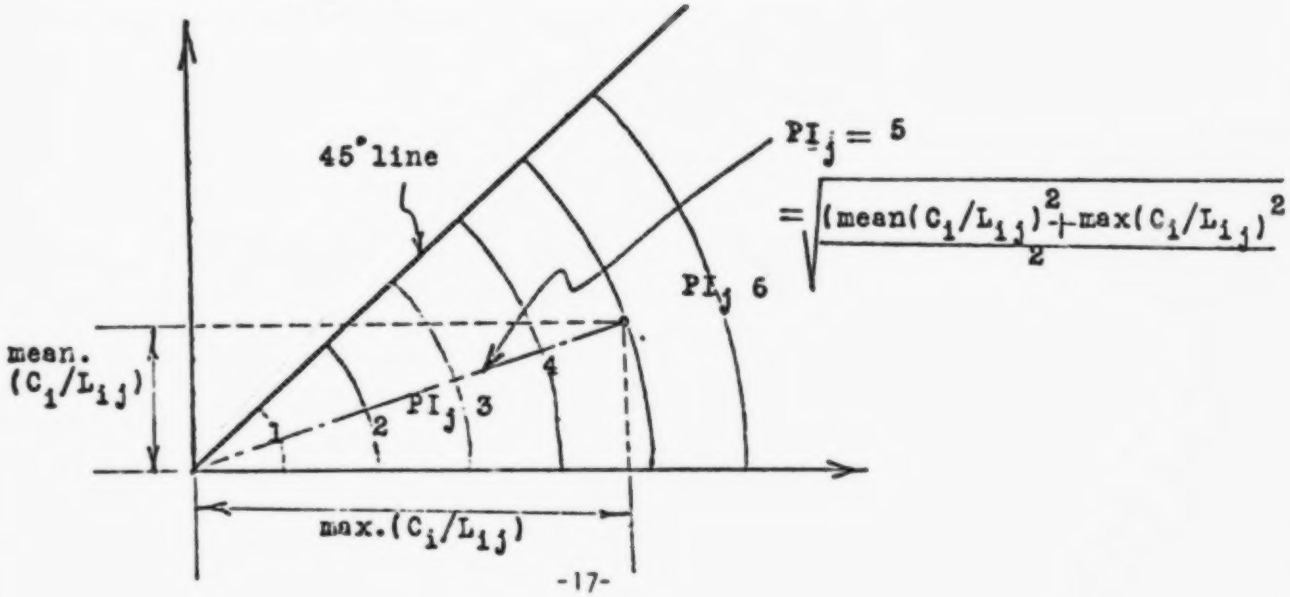
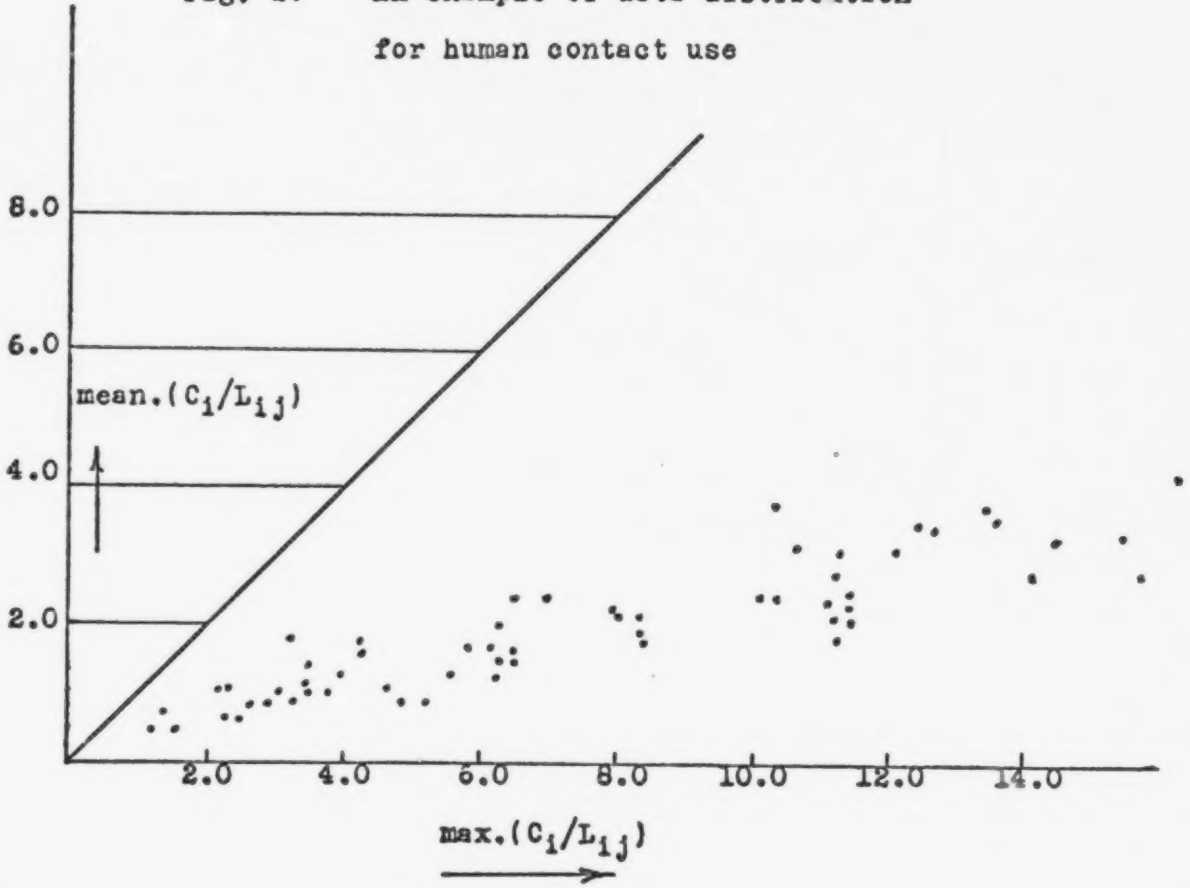

45° line
$PI_j = 5$
$= \sqrt{\frac{(\text{mean}(C_i/L_{ij})^2 + \max(C_i/L_{ij})^2}{2}}$
PI_j 6
mean.
(C_i/L_{ij})
1
2
PI_j 3
4
max.(C_i/L_{ij})

Fig.-2. An example of data distribution for human contact use



overall evaluation of this polluted water for the entire region may be quantified primarily according to the Index value for drinking use. However, the relative effects or importances of many regional uses mentioned above are not easily quantified. One possible procedure for establishing the overall Index, $\underline{PI}$, is proposed here. This procedure assumes that the relative effects are determinable as simple constant numbers in an overall estimation.

Judging from the fact that each PI_j value is a relative value, nondimensional, and the relative importance of each use may be generally determined as a constant value, the overall Index, $\underline{PI}_j$, is proposed here as a weighted average value of all the PI_j's as follows:

$$PI = \sum_{j=1}^{j=n} (w_j \cdot PI_j) \; .... \; (7)$$

Here,

w_j = Weight coefficient (constant value) which is determined by the relative importances of the water use j in the region or society.

n = Number of water uses.

and,

$$\sum^{j=n} (w_j) = 1.0 \; .... \; (8)$$

Additional Consideration for Pollution Index

Equation (6) is proposed as a general form of Pollution Index for water use j. However, some modifications are necessary in order to complete the actual Index.

First of all, calculation of the (C_i/L_{ij}) value will be discussed in more detail. Every item of water quality (C_i) does not always increase in concentration as pollution increases. But, on the other hand, pH values vary up or down with pollution, generally within a range from 2 to 12. Dissolved Oxygen (DO), for example, also usually decreases within a limited range as pollution mounts. In addition, it is common practice to specify the permissible level by a range of values such as pH from 6.4 to 7.5. In these special cases, (C_i/L_{ij}) value cannot be calculated in the same ways as previously suggested. Some general practical methods are recommended for some of these special cases.

a) For the contaminant which decreases in value as pollution increases, such as transparency, DO, etc.

The theoretical or practical maximum value (C_{im}) of the (C_i) value should be determined, such as DO concentration as saturation. The (C_i/L_{ij}) value may be replaced by (C_i/L_{ij}), where

$$\underline{(C_i/L_{ij})} = (C_{im} - C_i) / (C_{im} - L_{ij}) \text{ ....(9)}$$

For example, when maximum DO = 8.0 and the maximum permissible DO level is 4.0, and the existing level is 5.0.

$$\underline{C_1/L_{1j}} = (8.0 - 5.0) / (8.0 - 4.0) = 3/4 = 0.75$$

b) For the contaminant qualities which have permissible levels ranging from $L_{ij.\,min.}$ to $L_{ij.max.}$

The mean value of the ranged levels, $\bar{L}_{ij}$, should be calculated,

$$\bar{L}_{ij} = (L_{ij.\,min.} + L_{ij.\,max.}) / 2 \text{ .... (10)}$$

and the (C_i/L_{ij}) value may be substituted by the following;

$$\underline{(C_i/L_{ij})} = (C_i - \bar{L}_{ij}) / \left\{ \overset{*}{L}_{ij.min.} \text{ or } \overset{*}{L}_{ij.max.} - \bar{L}_{ij} \right\}$$

.............(10)

For example, if the maximum pH allowable level is 8.5 and the range is 6.5 to 8.5 when the existing pH 10.0, then

$$\underline{C_i;L_{ij}} = (10.0-7.5) / (8.5-7.5) = 2.5/1.0 = 2.5$$

Since an increase or decrease in acids or alkalies causing a pH change occurs on a logarithmic rather than an arithmetic scale, modification of the procedure using a log value of C_i/L_{ij} may be in order. More study of this point will be necessary since a log value will greatly (and perhaps disproportionately) affect the magnitude of the computed Index. For example, instead of 2.5 in the above example the number whose log is 2.5 is 316.

The (C_i/L_{ij}) value indicates relative pollution as compared to the respective permissible level. At the same time, this value also may express how damaging the water may be for use j, especially when the value is over 1.0. To illustrate the possibility, let us compare the (C_i/L_{ij}) values of 0.9 and 1.1. Both waters may be considered as almost equally polluted in a numerical meaning. However, this is not always valid in practice, because a treatment facility is necessary only for the latter water. Damages of the pollutants for uses which may be expressed in the necessary expenses for the facilities are generally quite significantly different from the numerically expressed values of 0.9 and 1.1. Likewise, when (C_i/L_{ij}) values of 5.0 and 10.0 are compared, the difference of the damages caused by both contaminants may not necessarily be so large as the values show. The necessary expenses for treatment are not always proportional to the quality of the raw water but generally diminishes in an increasing rate at PI values over 1.0. When the proposed Index is expected to reflect the relative damage of pollution rather than a simple numerical expression of the pollutants, some kind of calculation method of (C_i/L_{ij}) value should be considered to express the relative damage such as shown in Fig. 4.

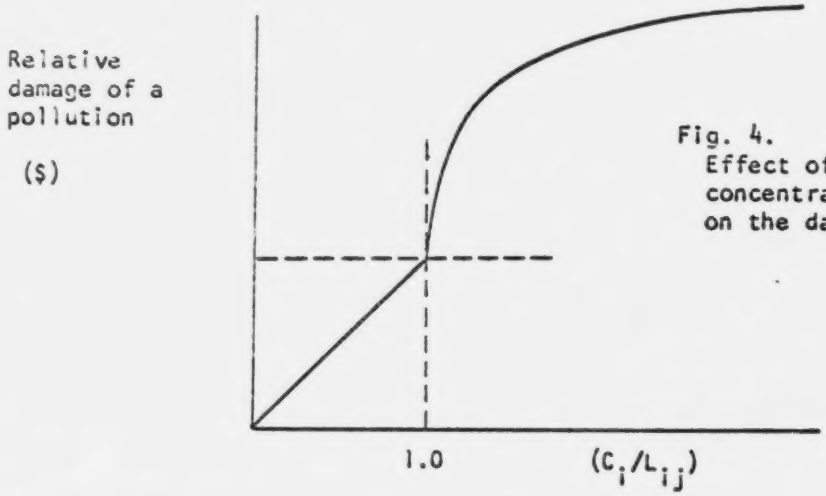


Fig. 4.
Effect of increasing concentration of pollutant on the damage costs

*Use whichever value is nearer to existing C_i value.

Assuming that the shape of the curve in Fig. - 4 is valid, the following calculation method is proposed here for the substitution of (C_i/L_{ij}) values. The existing data of the treatment costs are used. The following calculation of $\underline{(C_i/L_{ij})}$ value for each

(C_i/L_{ij}) may be substituted for the (C_i/L_{ij}) in equation (6) for PI_j.

$$\text{When } (C_i/L_{ij}) \leq 1.0, \ (C_i/L_{ij}) = (C_i/L_{ij})$$

$$\text{When } (C_i/L_{ij}) > 1.0, \ \underline{\overline{(C_i/L_{ij})}} = 1.0 + p.\log_{10} (C_i/L_{ij}) \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (11)$$

Here, p = a constant value

(As a standard value for a relative comparison, 5.0 is arbitrarily employed for p value in the later applications of the proposed Indices for the existing pollutions.)

Consideration is now given to the practical grouping of water qualities (i's) for the practical application of the proposed Indices. In the previous discussions, PI_j is proposed for each use j, (j = 1,2,3,...j...n), but the number of water uses (j's) are so numerous in a society that a collective general grouping of water uses may be used for practical purposes. If a reasonable common permissible level can be determined for similar water uses, grouping of water uses may be possible and facilitate calculation of the Pollution Indices. The following three groups are recommended for separate Index expressions:

1. Human Contact Use (j = 1) which included Drinking, Swimming, Beverage manufacturing, etc.
2. Indirect Contact Use (j = 2) which includes Fishing Industrial food preparation, Agricultural use, etc.
3. Remote Contact Use (j = 3) which included Industrial cooling, Aesthetic (picnicing, hiking and plain visitation), Navigation, etc.

The overall permissible levels (L_{ij}'s) should be determined for the three grouped uses by applying the present permissible contamination levels for each particular use. An example of the determination of the overall permissible levels for the grouped uses will be shown in the later part of this paper.

The following contaminant items (i's) are recommended for the

Index discussions and computations, although as many items of water qualities as possible should be utilized.

1. Temperature
2. Color
3. Turbidity
4. pH
5. Fecal coliform bacteria
6. Total dissolved solids
7. Suspended solids
8. Total Nitrogen
9. Alkalinity
10. Hardness
11. Chloride
12. Iron and Manganese
13. Sulfate
14. Dissolved Oxygen

Suitable contaminant items should be determined after considering the objective of the grouped use. In addition, one must make or have available water quality data including the data for the permissible levels.

SECTION VI

APPLICATIONS OF THE PROPOSED INDICES

As an application of the proposed Indices, pollution of the surface water resources in New York State will be quantified by the following procedure. These resources will be evaluated for human contact use (by PI_1), and indirect contact use (By PI_2) remote contact use (by PI_3), and also for general overall use (by $\underline{PI}$). The permissible quality levels for the above three grouped uses, (L_{i1}, L_{i2}, and L_{i3}), are determined as average permissible levels shown in Tables II, III, and IV. Permissible levels have been selected after careful study of the FWPCA; Interim Report of the National Technical Advisory Committee on Water Quality Criteria, June 30, 1967.

An example calculation of the Pollution Index (for human contact use, PI_1) of Oneida Lake in New York State is described in detail. First, the water qualities (2) of the Oneida Lake which are shown in Table V are divided by the respective permissible levels in Table II, and those calculations are summarized in Table VI. From the Table, Max. (C_i/L_{ij}) and mean. (C_i/L_{ij}) are given as 2.9 and 0.87 respectively.

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Table - II

Permissible quality levels for Human Contact Water Use (J = 1)
(F.W.P.C.A., 1967)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
	Temp	Color	Turb	pH	E.Coli	TS	SS	NO_3	Alk	Hard	Chl	Fe	Sulf	DO
	F	UNIT			100 ml	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
Drinking Use	-	15	5	-	5	500	-	45	-	-	250	0.35	250	
Swimming Use	85	-	-	6.5 8.3	-200	-	-	-	+	+	+	-+	-	-
Beverage Manufacturing	-	10	-	-	-	-	-	-	85	-	250	0.35	-	-/
Average; L_{ij}	85	13	5	6.5 8.3	-103	500	-	45	/	/	/	/	250	4.0*

Note: 1. (Temp.) Temperature 2.(Color); Color 3. (Turb.); Turbidity
5. (Coli); Coliform bacteria count 6. (TS); Total Solids
7. (SS); Total Suspended Solids 8. (NO.$_3$) Total Nitrate
9. (Alk); Alkalinity 10. (Hard); Hardness 11. (Chl); Chloride
12. (Fe); Iron and Manganese 13. (Sulf); Sulfate 14. D.O. (Dissolved Oxygen)

- ; Now under discussion
+ ; No special limit
/ ; L_{ij} is not determined because of the presence of (+) mark.
* ; Assumed

Table - III

Permissible quality levels for Indirect Contact Use (j = 2)
(F.W.P.C.A., 1967)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Fishing Use	55	-	30	6.0 to 9.0	-2000	-	-	-	-	+	-	-	-	-
Agricultural Use	-	+	-	6.0 to 8.5	-	500	-	45.	-	+	+	1.0	-	-
Fruit and Vegetable	+	5	5	6.5	-	500	.10	10	250	250	250	0.4	250	-
Industrial Use				6-8										
Average; L_{ij}	/	/	18	6.2 to 8.1	-2000	500	10	28	250	/	/	0.7	250	3.0*

Note: Agricultural use is Farmstead and Irrigation

Table - IV

Permissible quality levels for Remote Contact Use (j 3)
(F.W.P.C.A., 1967)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Iron & steel (cooling)	100	+	+	5-9	+	-	10	+	-	-	-	-	-	-
Cement	-	-	+	6.5 9.0	+	600	500	+	400		250	25.5	250	-
Petroleum				6.0- 9.0	+	1000	10	+	-	350	300	1.0	+	-
Pulp**	95	10	-	6.10	+	-	10	+	-	100	200	1.1	+	-
Textile***	-	5	-	6.4- 10.3	+	100	5	+	-	25	-	0.2	-	-
Chemical****	-	5	-	6.5 8.1	+	338	5	-	145	210	28	0.2	85	-
Navigation	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aesthetic	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Average, L_{ij}	98	/	/	6.1 9.1	/	510	90	/	274	171	195	5.6	/	2.0*

**; Bleached

***; Average of sizing, scouring, bleaching, and dying

****; Average of organic and inorganic matters

Note: For Navigation and Aesthetic uses, data for permissible levels are not available yet.

Table V - Water quality in Oneida Lake (New York State Dept. Health, 1964)
(Average data, 1960-1964)

Item	Quality	Item	Quality
Temperature C_1	63.3° F	Total Nitrogen C_8	-
Color C_2	12.0 unit	Alkalinity C_9	86 ppm
Turbidity C_3	12.0	Hardness C_{10}	128 ppm
pH C_4	8.2	Chloride C_{11}	26.0 ppm
Coliform C_5	72 MPN	Fe, Mn C_{12}	neg.
Total Solids C_6	209 ppm	Sulfate C_{13}	84.4 ppm
Suspended Solids C_7		Dissolved oxygen C_{14}	8.0 ppm

neg. = negligible

Table VI - Calculation of Index, PI_I for Oneida Lake.

i	$C_i/L_{ij})$	$\log_{10}(C_i/L_{ij})$	$\underline{(C_i/L_{ij})} = (C_i/L_{ij})$ or = 1.0 + $5\times\log_{10}(C_i/L_{ij})$
1	63.3/85.0=0.75	--	0.75
2	12.0/12.5=0.96	--	0.96
3	12.0/ 5.0=2.40	0.38	2.9 (max.)
4	** =0.89	--	0.89
5	72/103 =0.7	--	0.7
6	209/500 =0.42	--	0.42
7	-/-	-	-
8	-/4.5	-	-
9	86/-	-	-
10	128/-	-	-
11	26.0/-	-	-
12	0/-	-	-
13	84.4/250=0.34	--	0.34
14	*** =0.01	--	0.1
		Total	6.97
		Average (C_i/L_{ij}) = 6.97/ 8 = 0.87	

Note: - ; Datum is not available.

-- ; Calculation is not necessary

* ; Saturated concentration.

** ; (8.2 - (6.5 + 8.3) /2) / (8.3 - (6.5+8.3)/2) = 0.8/0.9=0.89

*** ; (8.4* - 8.0) / (8.4* - 4.0) = 0.1

Table - VII

Water Pollution of Surface Water Resources in New York State expressed by Pollution Indices.

cr. ; creek, Ri.;river, L. ; lake

Surface Water	Location	PI_1	PI_2	PI_3	PI
Niagara Ri.	Youngstown	6.0	1.4	0.2	2.5
Niagara Ri.	Buffalo	7.9	2.5	0.6	3.6
Erie L.	Buffalo	4.5	2.4	0.6	2.5
Cattaraugua Cr.	Gowanda	2.4	0.7	0.8	1.3
Buffalo Ri.	Buffalo	10.6	6.1	2.2	6.3
Cazenovia Cr.	Buffalo	9.4	4.8	1.0	5.1
Buffalo Ri.	W. Seneca	9.3	6.0	2.3	5.9
Buffalo Ri.	W. Seneca	11.8	7.8	0.9	6.8
Tonawanda Cr.	W. Seneca	3.2	1.7	2.1	2.3
Allegheny Ri.	Indian Res.	0.7	0.6	0.6	0.6
Conewango	Carroll	3.3	2.2	0.8	2.1
Cassadaga	Falconer	4.3	3.3	0.4	2.7
Ontario L.	Rochester	8.1	3.5	0.6	4.1
Allens Cr.	Brington	3.0	2.6	0.8	2.1
Ontario L.	Oswego	4.5	0.7	0.6	1.9
Genesee Ri.	Rochester	2.6	1.2	0.6	1.5
Genesee Ri.	Rochester	2.3	0.8	0.8	1.3
Genesee Ri.	Chili	2.6	1.3	1.5	1.8
Genesee Ri.	Wellsville	8.1	2.5	0.5	3.7
Chemung Ri.	Elmira	8.2	4.0	0.6	4.3
Cohocton Ri.	Campbell	3.4	0.8	0.7	1.6
Tioga Ri.	Lindley	2.7	0.6	0.7	1.3
Susquehanna Ri.	Binghamton	9.2	4.6	0.5	4.8
Chenango Ri.	Chenango	2.3	0.6	0.6	1.2
Toughnioga Ri.	Barber	2.6	0.7	0.6	1.3
Chenango	Chenango	0.8	0.6	0.6	0.7
Susquehanna	Unadilla	0.4	0.5	0.4	0.4
Seneca Ri.	Waterloo	4.7	0.7	0.6	2.0
Seneca Ri.	Geneva	1.1	0.8	0.7	0.9
Cayuga L.	Cayuga	8.1	1.5	0.6	3.4
Cayuga L.	Fayette	1.8	0.6	0.7	1.0
Owasco L.	Fleming	2.0	0.8	0.5	1.1
Skaneateles L.	Skaneateles	1.7	0.6	0.5	0.9
Canandaigua L.	Canandaigua	0.9	1.2	0.6	0.9
Seneca Ri.	Montezuma	4.7	0.8	0.6	2.0
Oswego Ri.	Oswego	10.3	5.5	4.0	6.6
Oneida L.	Cicero	2.1	0.8	0.6	1.1
Seneca Ri.	Clay	4.9	2.6	2.9	3.5
Black Ri.	Watertown	8.2	3.6	0.4	4.1
Black Ri.	Lyons Falls	8.3	3.7	0.4	4.1

Table - VII (Continued)

Surface Water	Location	PI_1	PI_2	PI_3	PI_4
Lawrence Ri.	Massena	4.7	2.6	0.6	2.6
Lawrence Ri.	Cape Vincent	0.8	1.1	0.4	0.8
Raquette Ri.	Massena	5.2	0.6	0.6	2.1
Gross Ri.	Massena	5.9	1.2	0.6	2.6
Oswegatchie Ri.	Ogdensburgh	6.5	2.0	0.4	3.0
Saranac Ri.	Shuyler Falls	8.3	3.7	0.5	4.2
Ausable Ri.	Ausable	6.1	1.4	0.5	2.7
Hudson Ri.	Waterford	8.1	3.5	0.6	4.1
Hosic Ri.	Schaghticoke	2.3	0.8	0.6	1.2
Hudson Ri.	Fort Edward	7.9	3.3	0.7	4.0
Battenkooll	Greenwich	5.9	1.4	0.6	2.6
Hudson Ri.	Orinth	6.1	1.5	0.6	2.7
Mohawk Ri.	Cohoes	4.3	1.3	0.5	2.0
Mohawk Ri.	Schenectady	0.6	0.7	0.4	0.6
Sheoharie Cr.	Frerida	7.4	2.8	0.5	3.6
Mohawk Ri.	Frerida	7.5	2.8	0.5	3.6
E. Canada Cr.	Manheim	8.3	3.7	0.3	4.1
Mohawk Ri.	St. Johnsville	8.1	3.6	0.5	4.1
W. Canada Cr.	Herkimer	8.3	3.7	0.5	4.2
Mohawk Ri.	Shuyler	1.8	0.8	0.7	1.1
Hudson	Poughkeepsie	4.6	2.7	0.7	2.7
Frishkill Cr.	Beacon	11.4	6.8	0.7	6.3
Wappinger Cr.	Lagrange	3.8	0.5	0.6	1.6
Wallkill	Rosendale	8.9	4.2	0.6	4.6
Hudson R	Poughkeepsie	9.9	5.4	0.4	5.2
Hudson Ri.	Bethlehem	11.4	6.6	0.3	6.1
Delaware Ri.	Port Jervis	0.4	0.1	0.3	0.3
Neversink Ri.	Deer Park	0.4	0.2	0.2	0.3
Delaware Ri.	Deposit	2.8	0.8	0.5	1.4
Hackensack Ri.	Orange Town	2.7	0.5	0.5	1.2
Pascack Cr.	Ramapo	10.2	5.3	0.5	5.3
Pascack Cr.	Clarkstown	11.9	7.3	0.5	6.6

Therefore, $PI_1 = \frac{2.9^2 + 0.87^2}{2} \doteq 2.1$

In the same way with the above, the PI_2 and PI_3 are also calculated using L_{i2} and L_{i3} in Table III and IV instead of L_{i1} (in Table II).

Then, $PI_2 = 0.8$

$PI_3 = 0.6$

The overall Pollution Index, $\underline{PI}$, is calculated by equation (7), applying the calculated PI_1, PI_2, and PI_3 values. But, the relative weight values, w_j's, in the equation are quite difficult to determine precisely from the existing available data. Therefore, the relative weights may be determined quite tentatively as follows, assuming that all water uses are equally important in our society.

$$w_1 = w_2 = w_3 = 1/3 \ldots\ldots\ldots\ldots (12)$$

Current water users, however, in Oneida Lake may be estimated quite roughly as follows; 40 % for swimming use, 40 % for fishing use, and 20% for navigation, aesthetic, and others. From these rough estimations, relative weight values may be possibly determined as follows; $w_1 = 0.4$, $w_2 = 0.4$, and $w_3 = 0.2$. Then, the overall Pollution Index for Oneida Lake is determined as follows:

$$\underline{PI} = w_1 . PI_1 + w_2 . PI_2 + w_3 . PI_3$$

$$= 0.4 \times 2.1 + 0.4 \times 0.8 + 0.2 \times 0.6 = 1.28^n = 1.3$$

The Pollution Indices for other surface water resources in New York State are quantified in a manner similar to that used for Oneida Lake. In the calculations, relation (12) is applied for relative weights (w_j's). The water quality data for those resources are obtained from "Periodic Report of Water Quality Surveilance Network, 1960 thru 1964" by New York, Department of Health. The results shown in Table - VII generally indicate the relative pollution of each water resource for our water uses. However, it should be emphasized that these are preliminary results, and are quantified here quite tentatively and mechanically as a trial application of the proposed Index method.

SECTION VII

ACKNOWLEDGEMENT

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SECTION VIII

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PART B - MEASUREMENT OF THE TOTAL DOLLAR BENEFIT OF WATER POLLUTION CONTROL

DEVELOPED BY

NELSON L. NEMEROW AND ROBERT C. FARO

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SECTION I

CONCLUSIONS

1. The dollar benefit of a lake or stream at a given water quality is determined by listing all uses which both affect and are affected by water quality, by valuing each use individually, and by summing the resultant values.

2. The beneficial water uses which are measurable and affected by or affect the water quality are categorized as recreation uses, withdrawal water uses, wastewater disposal uses, bordering land uses, and in-stream water uses.

3. The values of beneficial uses are measured by either a willingness to pay or an evaluation of benefits derived from avoiding payment. The value of these uses is estimated by taking surveys of the users at the lake or stream to determine the extent of demand for each use and the amount each user is willing to pay for a unit of use. This unit benefit is then multiplied by total demand to give annual dollar benefit for a particular use. Total annual dollar benefit at a given water quality is the sum of these benefits for each use.

4. Total annual dollar benefit at an improved water quality is estimated by determining the probable demand for beneficial water uses at the new quality. This demand is estimated by surveying the present demand for comparable uses at a nearby lake or stream with this new quality or it is estimated by questioning potential water users to determine latent demand for possible beneficial uses at this new quality which is presently being foregone.

5. Water-oriented recreation uses include sightseeing, walking and hiking, swimming, sport fishing, picnicking, boating, hunting, camping, water skiing, canoeing, sailing, and skin and scuba diving. These recreation uses are valued by including all of the expenditures incurred by the average recreationist as a measure of his willingness to pay. These include the costs of equipment, food, travel and park user fees.

6. Withdrawal water uses include municipal water supply, industrial water supply, and agricultural and farmstead water supply. The water quality benefits reflected in municipal water supply are computed to be at least equal to the cost of water treatment by chemical coagulation, sedimentation and rapid sand filtration. Those for industrial water supply are estimated by using water treatment costs, not to exceed those for municipal treatment. Agricultural and farmstead benefits are estimated as negative values if damages have occurred to irrigation, poultry and livestock watering, farmstead, or dairy uses.

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7. Wastewater disposal benefits which presently accure to waste dischargers are estimated to be equal to the costs of waste treatment required to meet existing pollution control standards. These costs include those for waste treatment plant construction and operation, industrial wastewater reduction, interceptor sewer construction, water quality surveillance, stream low-flow augmentation, in-stream aeration and complete removal of toxic, radioactive or high temperature effluents.

8. Bordering land value benefits for a particular land use at a given water quality are calculated by comparing the per acre market value of shoreline property with nearby non-shoreline property. These market values are computed by using local tax records and the tax equalization rates. The difference between the shoreline and non-shoreline per acre values reflect the unit benefits or damages of the shoreline location. Values at an improved water quality are estimated by applying this method to a nearby lake and by projecting the ratio of shoreline to non-shoreline per acre value back to the original lake at an improved quality.

9. In-stream water uses include commercial fishing, barge and ship navigation, flood control, and hydroelectric power generation. The value of commercially-caught fish is a positive value and is taken as a benefit while the other uses involve damages or negative benefits.

10. A net social benefit of at least 4.4 million dollars per year has been computed using this method and it will accrue to users of Onondaga Lake if the water quality is improved to support swimming, boating, sport fishing, municipal water supply and shoreline land uses.

11. Recreation proved to be the most important beneficial use for Onondaga Lake at improved water quality and its value comprises close to half of the total positive net annual benefits. Sport fishing is the most important recreation use, with sport fishing benefits comprising greater than 70 percent of the net annual recreation use benefits.

SECTION II

RECOMMENDATIONS

An economic analysis of Onondaga Lake indicates an estimated 4.4 million dollars in annual net social benefit which will accrue to water-using society with improved water quality. This writer believes the estimate to be conservative, especially in the area of recreation use benefits.

The procedure used in this benefit analysis should be useful to river basin administrators and pollution control authorities faced with the problem of deciding whether to spend money to improve the quality of streams and lakes. Several studies are now in progress to define possible methods for improving the water quality on Onondaga Lake and the corresponding annual costs. Combining these annual costs with the estimated annual social benefit resulting from improved water quality in a benefit-cost ratio will provide decision-making criteria for those responsible for pollution control.

In the Onondaga Lake example, some difficulty was experienced in estimating the recreation demand by the interspatial projection of demand from Green Lakes State Park. It was found that unit recreation demand or the expected number of visits per capita from each zone, $V(J)/P(J)$, was not completely dependent upon water quality. That is, there were some zones for Green Lakes State Park where the unit recreation demand was lower than that for corresponding zones at Onondaga Lake Park. The arbitrary assignment of Green Lakes unit recreation demand to Onondaga Lake would have created the false assumption that, for these four zones, the recreation demand in visits per capita from each of these zones would decrease if Onondaga Lake water quality were improved to that of Green Lake. This suggests that correction is necessary in order to use the unit recreation demand from a recreation area with high water quality to estimate recreation demand with improved water quality at a recreation area where water quality is presently low. The unit recreation demand must be compensated to reflect the effects of difference in physical characteristics of the recreation areas and differences in tastes of recreationists in corresponding zones for different areas.

Perhaps a more accurate method for determining the potential unit recreation demand for a recreation area with improved water quality is to mail a questionnaire or conduct a door-to-door survey of the population in the area bordering the lake or stream. However these also are often unreliable since people do not always act as they say they would under the improved water quality condition (Nemerow, 1968). The areal expance of this survey need not be overly extensive. In the Onondaga Lake example as it is noted in Table XIV, 66 percent of the visitors to Onondaga Lake Park originate from within Onondaga County and from Table XV, 84% are estimated to originate within a 20 mile radius from the park. It seems that the data obtained in this survey and the other surveys would be readily adaptable to digital computer storage and analysis.

A study of future demand for water-quality-related beneficial uses was not conducted for Onondaga Lake. The growth in demand for these beneficial uses may, in many cases, be correlated with the growth of the area population and may therefore be estimated quite closely by using a population projection. Specific recommendations include;

1. Water pollution control authorities, when faced with the problem of deciding the worth of installing any form of additional waste treatment, should allocate a portion of the overall budget to conduct a benefit analysis. Assume that a 10 mgd secondary waste treatment plant will cost 3.5 million dollars to construct. By using the newly-proposed method, this writer feels that an adequate benefit analysis to define the worth of this plant may be conducted at a cost of as little as one-half of one percent of the construction costs or $17,500.

2. Additional research effort should be concentrated on the determination of water-quality-related recreation use benefits. Sport fishing benefits should receive specific attention since sport fishermen incur relatively high costs and therefore show a high willingness to pay for this use. The considerable number of sport fishermen that crowded Lake Michigan during the summer of 1968 to harvest the Coho salmon serves as a good illustration of this fact.

3. A questionnaire should be mailed or a door-to-door survey should be conducted of the population in the area bordering a lake or stream of low quality to determine potential recreation demand at an improved water quality.

4. Projections should be made for future recreation benefits at Onondaga Lake with improved water quality by correlating growth in recreation demand and other beneficial uses with the population growth.

5. The political, legal, and administrative feasibility of creating "river basin firms" to make economic decisions and to allocate the dwindling natural resources on an equitable basis should be investigated.

SECTION III

INTRODUCTION

Why Measure the Benefits of Water Pollution Control?

During the past half century, the art of sanitary engineering has developed rather sophisticated mechanical, chemical, and biological techniques for purging wastewaters of undesirable contaminants. These processes have been developed through the motivation of definite needs in particular cases. Usually the need for providing an increased degree of treatment for a sewage or an industrial waste existed long before the treatment process was installed. The need was usually quite clearly defined; that is, a waste discharge was creating a definite public health menace by contaminating a public water supply, a waste discharge was causing deposition of sludge banks of organic material in a stream which decomposed, creating odoriferous, paint-blackening hydrogen sulfide gas in residential areas, or fish kills in a fine fishing stream were directly attributable to an industrial waste being discharged. These problems could usually be economically remedied by removing specific contaminants or fifty to eighty-five percent of the organic constituents of the waste stream.

Today, we in the United States have the same quantity of water in our streams and lakes and the same amount of rainfall for dilution purposes, that we have always had in historic times. But now we find that the quantity of water-borne wastes has risen sharply and will continue to rise with increased population and industrial growth. We know that each lake and stream has a definite limit on the quantity of waste it can absorb and still satisfy other beneficial uses. Therefore, in order to maintain even a constant water quality we must continue to remove ever increasing amounts of contaminants from our wastewaters. The disheartening truth we must face is that to achieve removal of higher percentages of contaminants, even greater than ninety-nine percent in many cases is necessary, requires perhaps four or five times the costs of our present waste treatment practices. The immediate question that arises and one that must be answered is: "Is it worth it?", "Do the benefits which accrue to water-using society justify the increasing costs of waste treatment?"

The federal and state governments have decided that the benefits which accrue to society do justify the increasing costs of waste treatment and they:

> have attempted by laws, education, gentle persuasion, conferences, and court decisions to regulate the increasing amount of contaminating matter entering our water courses. The "gap" between water as a free commodity and the tremendous sums required to keep water from being contaminated has been too wide for regulation alone to be effective. (Nemerow, 1966a:3)*

As an alternative to regulation, various authorities have advanced the recommendation of using effluent charges to effectively control mounting pollution.

Both the government-regulation and effluent-charge methods of administration require that the real benefits arising from water quality control and pollution abatement be quantified. This is necessary "so that both industry and the public will be in a position to examine the economics of a given waste treatment situation." (Nemerow, 1966a:2)

Kneese (1967:710) has pointed out that principles of welfare economics must be used to determine water quality benefits:

> Economics is a theory of social values. Our society has the value judgement that individual tastes and values are to govern the uses of resources in a free society. The Flood Control Act of 1935 enunciated a general welfare economics criterion when it indicated that projects should be considered justified if, "the benefits, to whomsoever they accrue, exceed the cost."

In the past, most of the real benefits which resulted from waste treatment were considered "irreducibles." This is primarily because no one has been willing or able to put a dollar value on them (Nemerow, 1966B).

How to Measure Benefits?

The engineer is rather reluctant to become involved in a study of benefits since this area has been considered the realm of the economist. When the engineer considers the construction of a waste treatment plant, he is able to predict, within relatively small tolerances, the cost of the completed facility. He may accurately estimate the cost of the acquisition and preparation, he can compute the in-place cost of reinforced concrete and structural steel from current market prices, he may obtain the installed costs of various mechanical and electrical components from suppliers and he may estimate the cost of borrowing money to fund the project. By simply summing the individual costs of all portions of the project, he may calculate the total cost.

The economist, when considering the benefits of a given project, may desire to use a technique similar to engineering cost estimating. That is, to establish separate units of benefit measure and to multiply.

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*Literature cited is listed alphabetically at the back of this paper. The citation appears as the surname of the author first, followed by the year of publication and the page number for a direct quotation.

the number of these separate units used, by the average market price per unit to obtain the total value of each benefit. The summing of these separate benefits then would give total benefits for the project. He is immediately faced with several problems: (1) How may the separate units of benefits be defined? (2) How to determine the n8mber of separate benefit units which will be demanded for future use? and (3) What unit beneficial value to select in the absence of a market price per unit?

How May the Separate Units of Water Quality Benefits Be Defined?

The benefits associated with the quality of a particular body of water are intimately related to the uses which society desires to make of the particular lake or stream. Therefore, the separate units of water quality benefits may be listed by listing each possible beneficial use of the water. This list will become extensive but these beneficial uses may be broadly categorized as shown in Table I.

TABLE I

Categories of Beneficial Water Uses

1. Recreation Uses
2. Withdrawal Water Uses
3. Wastewater Disposal Uses
4. Bordering Land Uses
5. In-stream Water Uses

It is realized that many of these beneficial water uses are not mutually compatible, such as swimming and waste disposal. Therefore each quality level in a given body of water will produce a heirarchy of beneficial uses. The greatest beneficial uses will change with the quality. Categorizing the beneficial uses and eventually identifying and summing the dollar benefits, at varying quality levels will thus allow administrators to decide the worth of various waste treatment alternatives.

How to Determine the Number of Separate Benefit Units Which Will be Demanded for Future Use?

Any attempt to determine future demand for a specific beneficial use is necessarily a guess. This demand may be estimated by two methods: (1) The intertemporal method, by measuring the past and present demand for the use at the site and then on the basis of the trend, projecting future demand. (2) The interspatial method, by measuring the present demand at another site where the physical conditions of the site and the nature of demand are comparable to those that will occur at the study site in the future.

What Unit Beneficial Value to Select in the Absence of a Market Price per Unit?

Economists generally agree that in a free market "the prices of goods and factors of production accurately represent their contributions to social welfare," (Kneese, 1964:39), and thus social benefits. The market mechanism establishes the value and produces an equal standard of measure for different goods and services on the basis of the willingness of consumers to pay for them (Kneese, 1966; Gaffney, 1967). In the absence of a market price for a given water use, a measure of the user's willingness to pay may be substituted in order to measure benefits. Of the five general categories of beneficial water uses listed in Table I, only the value of bordering land may be represented by a valid market price. The other four categories demand that we establish a substitute for a market price based upon the willingness of water users to pay.

The willingness to pay measure may also be extended to include pollution damages which users incur, since damages are dollars which the consumer must pay or forego with continued use of the resource.

SECTION IV

TOTAL ANNUAL SOCIAL BENEFIT AT A PARTICULAR LEVEL OF WATER QUALITY

The problem is to determine the value which the public attaches to water containing pollution and to estimate the increase in value of these same waters with a decrease in pollution. The public's willingness to pay for water uses will be used as the measure of value.

We believe that the only acceptable method of measuring the social benefits of water pollution control for a specific water body is to categorize them in classes based on water uses and then to conduct surveys of the water body to measure the extent of public demand at existing quality levels. These surveys will cover the five categories of beneficial uses listed in Table I. Future demand at different quality levels should be determined by an intertemporal projection of existing demand or an interspatial study of a similar water body at the new quality level.

It has been suggested that the degree of pollution of a body of water may be measured by a pollution index (PI). The pollution index is a numerical constant at a given level of water quality and is composed of thirteen parameters consisting of temperature, color, turbidity, pH, coliform bacteria count, total solids, suspended solids, total nitrogen, alkalinity, hardness, chlorides, iron and manganese, and sulfates (See Part A).

The dollar benefit of a particular water use at a given quality level is the average demand in units of use multiplied by the average willingness to pay for a unit of use. The total annual social benefit or value of a particular water body at a given water quality may be determined by summing the benefits obtained in the five surveys. Therefore, at a given level of pollution, pollution index PI equals a constant (C(I), referred to as PI = C(L):

$$B = B(R) + B(WI) + B(WD) + B(L) + B(IS)$$

where B = The total annual social benefit of the water resource at PI = C(L).

B(R) = Annual recreation use benefits.
B(WI) = Annual withdrawal water use benefits.
B(WD) = Annual wastewater disposal benefits.
B(L) = Annual bordering land use benefits.
B(IS) = Annual in-stream water use benefits.

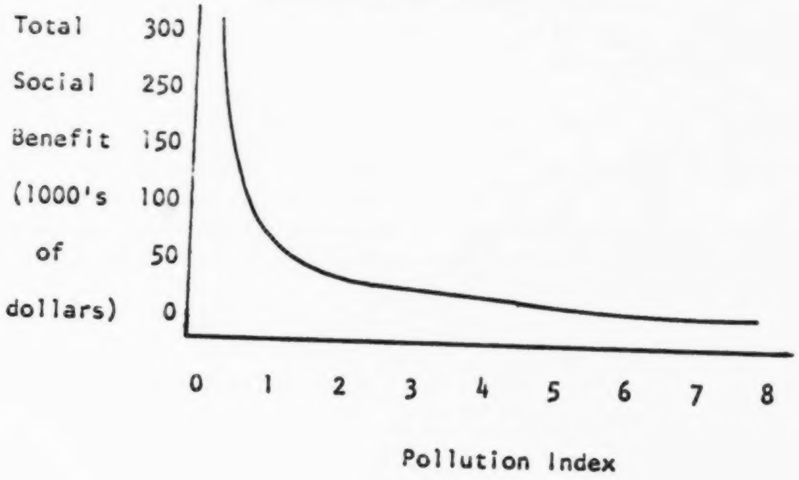
The value of the same body of water at a different water quality, PI=C(2), may be estimated by the interspatial method if the new pollution index represents the quality of a nearby body of water with physical characteristics other than water quality, which are similar to the first. A survey of present water uses at the second body of water should produce a demand relation which may be applied to the original body of water. If differences exist in physical characteristics which are quantifiable, such as, beach area available for swimming, the demand projection from the second to the first body of water may be compensated by an appropriate factor, such as the ratio of the areas.

Similarly, by the intertemporal method, the value of the original body of water at a different water quality, PI = C(3), may be estimated by setting forth uses which the body of water could support at this quality and by projection of the future demand for these uses from existing demand data.

Therefore, a curve of water quality benefits versus po-lution index may be plotted for a given body of water, with the number of points on the curve corresponding to the number of interspatial or intertemporal studies which were conducted. A hypothetical curve is shown in Figure 1.

Figure 1

Value of Water Quality Control
For a Hypothetical Lake



SECTION V

RECREATION USE SURVEY

Recreation Use Benefits

The Recreation Use Survey has been listed as the first survey to be conducted. In the United States, most agencies involved in the measurement of the benefits of water quality control estimate that the greatest dollar benefits will accrue to recreation users. The procedure proposed in this research for the measurement of the monetary value of water-based recreation is one that estimates present and future demand for specific uses, that incorporate the total expenditures of the recreation user as a valid measure of the consumer's willingness to pay in the absence of market prices (Whiteley, 1968) and that sums the product of units of demand times the dollar value of the consumer's willingness to pay per unit to obtain total recreation use benefits.

Other researchers in the area of recreation economics have measured recreation benefits by "estimating what a discriminating monopolist might be able to extract from each recreationist" (Whiteley, 1968:842) through the charging of added user fees at the site. This procedure was originated by Hotelling (1949) and described by Stevens (1966:168):

> He suggested defining concentric zones around the recreational site, so that travel costs would be approximately constant within each zone. This definition would enable the formation of a demand curve, in that travel cost from each zone would be plotted together with the number of visitors from that zone. Users from the closer zones would enjoy a "consumer surplus" by not having to pay the full travel costs of users in the more distant zones. Integration of the area under the demand curve would indicate the extent of consumer surplus and thus afford an estimate of the recreational value of the site.

Stevens (1966) and Clawson and Knetsch (1966) describe thoroughly the basis and justification for the use of consumer surplus for measuring benefits. Basically, recreation benefits are considered to be only those dollars which a monopolist could recover from recreation users as entrance fees at the recreation site. This is necessarily a highly conservative view in that it reflects only a portion of the recreation user's willingness to pay. He also spends significant amounts of money in the home community, and enroute, in addition to that spent or able to be spent at the recreation site.

We believe that gross expenditures by recrationists should be used to value water-oriented outdoor recreation. The data in Table II show that for the major outdoor recreation activities, generally

Table II

Percent of U. S. adults engaging often, and a few times, in selected outdoor activities, by location of residence of the person, 1959-60.

Activity & Frequency		Percent engaging in activity			
		Cities	Residence Suburban Areas	Adjacent Areas	Outlying Areas
Outdoor swimming or going to a beach	More than 4 times	23	36	28	18
	1 - 4 times	21	22	17	16
Fishing	More than 4 times	13	19	22	26
	1 - 4 times	16	19	16	20
Hunting	More than 4 times	5	7	10	14
	1 - 4 times	5	6	9	14
Driving for sight-seeing and relaxation	More than 4 times	46	49	50	42
	1 - 4 times	23	24	24	23
Picnics	More than 4 times	29	37	32	27
	1 - 4 times	36	35	34	32
Camping	More than 4 times	5	8	5	8
	1-4 times	5	9	8	12

Note: Cities are urban places of 50,000 population or more; suburban areas immediately surround these cities; adjacent areas extend beyond suburban areas to a distance of 50 miles; outlying areas are at least 50 miles from a city of 50,000 population or more.

Source: ORRRC, 1962b:218

over fifty percent of those adults who engage in the activities, do so more than four times per year. After a person partakes of a given form of recreation more than once, we may safely assume that it was at least worth what he spent to participate. This cost represents aggregate willingness to pay and therefore, it is a better measure of social benefits than is consumer surplus.

We are not interested in capturing dollars as a monopolist seeking a profit but in imputing a realisitic dollar value on water-oriented recreation by selecting user's willingness to pay as a valid measure and in totaling these benefits "to whomsoever they accrue" (Kneese, 1967:710).

Since travel and travel-associated costs constitute a considerable portion of the gross expenditures of the recreation user, the geographic analysis method employed by Clawson and Knetsch (1966) for determining total travel costs is considered valid and useful. They (Clawson and Knetsch, 1966:64) defend this geographic approach by saying that:

> We must accept the pattern of population distribution, of distribution of recreation areas, of income of the population, of transportation facilities, of use of the recreation areas and other factors as we find them.

We use the zone technique to determine the variable travel costs to the recreation area.

The Bureau of Outdoor Recreation considers the outdoor recreation activities listed in Table IV as those most important in association with water and water quality. Water dependent recreation activities are those which could not be carried out without the use of a body of water while water-enhanced recreation activities are those which are enhanced by the presence of a body of water but can be carried out in the absence of water.

Table III

Outdoor Recreation Activities Most Important in Association with Water and Water Quality

Water-Dependent	Water-Enhanced
1. Swimming	1. Camping
2. Fishing	2. Picnicking
3. Boating	3. Sightseeing
4. Water-skiing	4. Nature Walks
5. Canoeing	5. Hiking
6. Sailing	6. Hunting

Data Collection for the Recreation Use Survey

In order to construct a demand schedule for water-based recreation, it is suggested that the following items be completed in the data collection portion of the recreation use survey:

1. Location

Locate the lake or stream on a map showing village, residential development, city ward, township, county, state and federal boundaries.

2. Interspatial Areas for Comparison

List all present and potential water recreation areas within fifty to one hundred miles of the lake or stream under consideration.

3. Travel Distance Zones of Each Zone

Delineate twenty concentric mileage zones of visitor origin at progressively increasing distances from the recreation lake or stream. Let (J) be the zone number and let D (J) be the average one-way distance in miles from the center of the zone of origin (J) to the recreation site. The areas of origin within a specific zone should be based on existing political or census subdivisions.

The areas of origin should be smallest and most specific the nearest to the recreation site and then increase in size with increasing distance from the site. It is suggested that the mileages listed in Table IV be used to delineate zones and the political subdivisions for areas within zones.

4. Population Determination of Each Zone

Determine the population of each zone or origin (J) using data from the most recent census. Census population data is presented by city census division, towns and villages. A census map with the zone boundaries marked will show within which zone a particular census division falls. A town may fall in as many as four zones. The population of a zone may be calculated by summing the parts contributed by each census division . Let P(J) equal the population of zone (J).

5. Annual Recreation Attendance

Determine the annual recreation attendance at the recreation area bordering the lake or stream to be studied. Recreation attendance may be measured in recreation days. A recreation day is defined as:

Table IV

Concentric Mileage Zones of Visitor Origin About Water Body

$J_{(1)}$	Mileage Range	D(J) (2)	Political Subdivision
1	0 - 2	1	Village, Town
2	2 - 4	3	Residential
3	4 - 6	5	Development,
4	6 - 10	8	City Ward
5	10 - 15	12.5	
6	15 - 20	17.5	
7	20 - 25	22.5	Township,
8	25 - 30	27.5	City
9	30 - 40	35	
10	40 - 50	45	
11	50 - 60	55	
12	60 - 80	70	
13	80 - 100	90	County
14	100 - 150	125	
15	150 - 200	175	
16	200 - 300	250	
17	300 - 500	400	State,
18	500 - 1000	750	Province,
19	1000 - 2000	1500	Territory,
20	>2000		County

(1) Zone number, (2) Average One-way Distance in Miles

> A visit by one individual to a recreation development or area for recreation purposes during a reasonable portion or all of a 24-hour period (Bureau of Outdoor Recreation, 1967:1-4).

Base the attendance on an annual recreation season and use park authority records of daily visits to obtain data. Let V equal the total annual recreation days for the area.

6. Average Recreation Participation per Visit by Use and Zone

Conduct a survey of visitors to the recreation area. Determine recreation demand by questioning a sample of visitors. Determine the average visitor participation per visit for each recreation use (L) by visitors from each zone (J). Units of recreation use may be measured in visitor-days with one visitor-day being:

> The presence of one or more persons on lands or waters, generally recognized as providing outdoor recreation, for continuous, intermittent or simultaneous periods of time totaling twelve hours (Hawkins and Tindall, 1966:2).

Itemize the recreation use in visitor-days per visit based on the twelve different uses listed in Table V and the twenty different zones or origin listed in Table IV. The Bureau of Outdoor Recreation (1967) assumes that the average person participates in 2.5 activities during an average visit to a recreation area. Let N (I,J) equal the number of visitor-days per visit demanded for recreation use (I) by visitors from zone (J).

Also determine the zone of origin (J) for each visitor questioned in the survey. Let VS (J) equal the total number of sample visits from zone (J).

It may be advantageous to preserve the visitor origin by the specific political division in the zero to fifty miles range, instead of grouping in mileage zones only. These values may be useful in determining the specific recreation demand of a particular village, residential development, or city ward.

The attendance measurements for various uses by visitors from various zones should be based on a sampling technique which produces results which are representative with a high probability of accuracy. Care should be taken to sample during periods of minimum demand such as rainy days, weekends, and evenings as well as during periods of peak demand, on sunny weekends and holidays. A proper statistical method should be selected.

Table V

Water Based Recreation Uses

Recreation Use	Value of Index (1)
Sightseeing	1
Walking and Hiking	2
Swimming	3
Fishing (Warm, Cold & Salt Water)	4
Picnicking	5
Boating	6
Hunting	7
Camping (Temt, Trailer & Group)	8
Water Skiing	9
Canoeing	10
Sailing	11
Skin & Scuba Diving	12

7. Base Cost Per Visit for Each Use

Determine a base cost per visit for the recreation uses listed in Table V. Include all expenditures made by the average recreationist to participate in the particular recreation activity, other than travel and travel associated costs. This data may be obtained from private and governmental; local, state, and national recreation organizations, but care should be exercised to assure that general costs apply to the specific area. Costs for general recreation uses such as camping may be reported such that they include expenses for other more definite lesser uses such as swimming. Let R(I) = Base Cost per Visit for Use (I).

The base cost per visitor-day for a given water recreation use should be fairly constant for the general local area of the study. This area would usually be a collection of several counties, an area of, say 10,000 to 40,000 square miles (100 x 100 miles to 200 x 200 miles). An average value should adequately represent the true value in this area of limited extent.

The base cost per visitor-day should include money spent at the recreation site plus the unit cost per visitor-day for equipment and supplies necessary to perform the given type of recreation.

Items of the following nature will fall in the category of money spent at the recreation site: park entrance fees; money spent at concessions; the cost of rental of recreation equipment, such as boats and canoes; the fees for bath house use at the beach; the cost of cabin rental for overnight stays; the cost of rental of camp site or trailer site; fees for boat launching; parking fees; the cost of fish bait; and the cost of food, over and above that cost which would have been incurred at home (usually spent at restaurants and for groceries).

In the category of money spent for equipment are all of the expenses incurred at home in preparation for the recreation experience. The unit cost per visitor-day for the use of this equipment may be calculated as being its original total cost less its salvage value, divided by the number of uses during its useful lifetime. The equipment costs may include the costs of: boats; motors; canoes; sailboats; boat registrations; boat trailers; water skis and accessories; swimming equipment including suits, floats and other water toys; special clothing costs such as shoes for hiking, hunting clothes for duck hunters; camping equipment including tents, tent trailers, camper trailers, stoves, lanterns, cooking utensils, cots, air matresses, folding chairs, sleeping bags, knives, axes, packs; fishing equipment; fishing licenses, hunting licenses; federal duck stamps; special vehicles, such as jeeps, amphibious cars, hunting equipment including guns, decoys; and skin-diving equipment such as air tanks, face masks and wet suits.

These values may be obtained from the users themselves by sending questionnaires to each specific group of users, such as obtained from boat registration lists, and hunting license lists. Values also may be obtained from local organizations of sportsmen including rod and gun clubs and others. Initial estimates may be corrected later in the survey to achieve greater accuracy, when additional data is made available during the study.

8. Automobile Travel Costs

Determine the average cost per mile for automobile travel including gas, oil, tires, repairs, registration, insurance and depreciation. Let K equal the costs per mile. This will generally be on the order of ten to fifteen cents per mile.

9. Travel Associated Costs

Determine the average cost per visit to visitors from each zone, for travel associated costs, such as restaurant meals, motel accommodations and tourist goods. Let $A(J)$ = Cost per Visit, Zone (J). These travel associated costs will be costs other than direct automobile expenses which have been incurred in traveling to and returning from the recreation site. They should include the cost of food over and above the cost which would have been incurred at home, that is, expenses for restaurant meals and for additional or more expensive groceries; hotel or motel expenses for overnight stays, the cost of tourist goods and services purchases on the trip and any other expenses, other than those for automobile use which will be incurred during travel to the site and would not have been otherwise incurred.

Total travel costs per visit $\{T(J) = 2 \times K \times D(J) + A(J)\}$ may not be completely chargeable to the water recreation experience at the site if the visitor has come to the area for other purposes in addition to water recreation. These total costs cannot be assigned as benefits which reflect the user's willingness to pay since not all of these costs to visitors from all zones are attributable to the water recreation experience. Instead, as the point of visitor origin moves progressively further from the recreation area, the visit to the recreation area becomes a small percentage of the total purpose of the trip. Over one hundred miles distant, the purpose of the visit becomes a progressively smaller percent of the total purpose of the trip. The travel cost $T(J)$ per visit to visitors from a distance over one hundred miles, assigned as benefits thus should decrease as the ratio of the purpose of the visit to the purpose of the trip decreases. Clawson and Knetsch (1966) suggest that a cost sharing technique be applied with that portion of the costs being allocated to the water recreation is to the whole purpose of the trip.

10. Annual Additional Cost of Water Recreation Area Maintenance and Operation

Determine the annual cost of water recreation area maintenance and operation that is not covered by money received from user charges. That is, money which must be paid by federal, state or local governments for the maintenance and upkeep of the park. Let G equal the annual additional cost of park maintenance and operation.

11. Other Areas in the Interspatial Survey

Carry out steps three through ten for every other present and potential water recreation area listed in step two.

Data Calculation for the Recreation Use Survey

The following calculations should be made in order to determine the total annual recreation use benefits, B(R), for a given water recreation site:

1. Annual Recreation Demand by Use and Zone

Determine the annual recreation demand for each recreation use (I) by visitors from zone (J) as follows:

The total sample size of visitors questioned in the survey is:

$$VS = \sum_{J=1}^{20} VS(J)$$

The total annual number of visits from zone (J) is:

$$V(J) = VS(J) \times V/VS$$

The annual recreation demand in visitor-days for recreation use (I) by visitors from zone (J) is:

$$V(I,J) = V(J) \times N(I,J)$$

2. Travel Cost per Visit

The travel cost per visit for visitors from each zone (J) is:

$$T(J) = 2 \times K \times D(J) + A(J)$$

3. Total Cost per Visitor-day for Each Use and Zone

The total cost per visitor-day for each use (I) to visitors from zone (J) is:

$$C(I,J) = \frac{R(I) + T(J)}{N(I,J)} = \frac{R(I) + 2 \times K \times D(J) + A(J)}{N(I,J)}$$

4. Total Annual Recreation Benefits for a Particular Use

The total annual recreation use benefits for the water body are:

$$B(R) = \sum_{I=1}^{12} B(I) + G = \sum_{I=1}^{20} \sum_{J=1}^{20} V(I,J) \times C(I,J) + G$$

This value may be related to the level of water quality for the particular recreation area with the use of the pollution index, $PI=C(1)$.

5. Unit Recreation Demand for Each Use and Zone

The unit recreation demand for recreation use (I) exhibited by the population of zone (J) may be calculated as:

$\frac{V(I,J)}{P(J)}$ = Visitor-days per person for use (I) by the population of zone (J)

The unit recreation demand may be used to estimate the recreation demand at the water body at a new water quality (Pollution Index) in an interspatial comparison with another nearby water body at a different water quality. If differences in physical characteristics and degree of crowding of the recreation areas are compensated by appropriate weighting factors for each use (I). The compensated unit recreation demand should reflect changes in water quality, as illustrated in the following paragraph.

Consider a recreation area, 2, with water quality $PI = C(2)$, differing from that of the first recreation area, 1, $PI = C(1)$. The potential recreation demand for recreation area 2 at a pollution index which corresponds to that of area 1, $PI = C(1)$ may be estimated by assuming that the compensating unit recreation demand as recreation use in visitor-days per person, for use (I) and zone (J), is the same for both recreation areas when their pollution indices are equal. That is,

when $$PI = C(I) = C(2)$$

then $$\frac{V(I,J)}{P(J)} \quad (2) = \frac{V(I,J)}{P(J)} \quad (1)$$

and $$V(I,J) \quad (2) = \frac{V(I,J)}{P(J)} \quad (1) \times P(J) \quad (2)$$

and potential total use benefits for recreation use (I) become:

$$B\,(I) \quad (2) = \sum_{J=1}^{20} V(I,J) \quad (2) \times C(I,J)$$

and potential total recreation use benefits at recreation area 2 are:

$$B(R)\quad(2) = \sum_{I=1}^{12} B(I)\quad(2) + G(2) =$$

$$\sum_{I=1}^{12}\sum_{I=1}^{20} V(I,J)\quad(2) \times C(I,J) + G(2)$$

SECTION VI

WITHDRAWAL WATER USE SURVEY

The withdrawal water use survey will attempt to evaluate the benefits arising from uses which involve the withdrawal of water from a lake or stream. These withdrawal uses will include municipal water supply, industrial water supply and agricultural and farmstead water supply.

A. Municipal Water Supply

1. Data Collection for the Municipal Water Use Survey

The writers recommend that in order to determine the water quality benefits assignable to a given body of water for municipal water supply the following data should be gathered for the municipalities in the study area;

a. Local Water Utilities

Locate all municipal and private water utilities in the study area and their sources of water supply, giving the exact location of the water intake.

b. Present Water Demand

For each utility determine the total annual water usage, the annual average daily water usage, the annual peak hourly water usage and the total number of customers served.

c. Present Water Treatment

Describe the extent of water treatment being practiced by completing the checklist shown in Table VI.

d. Annual Cost of Water Treatment

Determine the total annual cost of water treatment for each utility. Do not include the cost of collection and distribution unless special equipment is required due to the nature or location of the treatment plant. Include the following costs:

(A) Capital costs composed of principal and interest payments.

(B) Constant costs composed of labor, taxes and insurance.

(C) Costs directly proportional to plant capacity composed of maintenance of structures, equipment and grounds.

(D) Costs directly proportional to production composed of chemicals, electric power, gas or oil for heating, and operational labor.

Table VI

The Extent of Water Treatment

Lake or River Reach ______________________________

Municipal Water Utility ______________________________

Location of Water Intake ______________________________

Total Annual Water Usage ______________________________

Annual Peak Daily Water Usage ______________________________

Total Customers Served ______________________________

Extent of Water Treatment

______ None

______ Disinfection

    ______ Prechlorination

    ______ Postchlorination

    ______ Chemical dosage (lbs per mg) (1)

    ______ Calcium hypochloride Ca $(OCl)_2$

    ______ Sodium hypochlorite $NaOCl$

______ Turbidity Removal

    ______ Chemical Coagulation

        ______ Coagulants added (dosage in lbs per mg)

            ______ Alum $Al_2 (SO_4)_3 \cdot 18H_2O$

            ______ Ferric Chloride $FeCl_3$

---

(1) One lb per mg (pound per million gallons) equals 0.1198 milligrams per liter.

Table VI (Cont.)

_____Ferric Sulfate $Fe_2(SO_4)_3$

_____Chlorinated copperas ($FeCl_3 + Fe_2(SO_4)_3$)

_____Aluminum chloride $AlCl_3$

_____Sodium aluminate $NaAlO_2$

_____Activated alum (with silica SiO_2

_____Black alum (with activated carbon)

_____pH Adjustment

_____Downward (dosage in lbs per mg)

_____Sulfuric acid H_2SO_4

_____Carbon Dioxide CO_2

_____Hydrochloric acid HCl

_____Sodium aluminate $NaAlO_2$

_____Upward (dosage in lbs per mg)

_____Hydrated lime $Ca(OH)_2$

_____Caustic soda NaOH

_____Soda Ash Na_2CO_3

_____Sodium bicarbonate $NaHCO_3$

_____Materials to add weight to floc (dosage in lbs per mg)

_____Floc clays (bentonite, Kaolinite)

_____Powdered limestone $CaCO_3$

_____Sedimentation

_____Solids Contact Clarifier

_____Sand Filter

Table VI (cont.)

_____Slow

_____Rapid

_____Filter media depth, inches (2)

_____Anthracite depth, inches

_____Quartz sand depth, inches

_____Garnet sand depth, inches

_____Pressure filters

_____Number of filters

_____Area per filter, square feet (3)

_____Design filtration rate, gallons per square foot per minute (4)

_____Diatomaceous earth filter

_____Filter aid used (lbs per mg)

_____Filter area, square feet

_____Microstrainer

_____Screen area, square feet

_____Screen size, microns

_____25u

_____35u

_____50u

---

(2) One inch equals 2.54 centimeters.
(3) One square foot equals 0.09290 square meters.
(4) One gallon per square foot per minute equals 0.122 cubic meters per square meter per minute.

Table VI (Cont.)

- _____Softening-Calcium Removal
  - _____Ion Exchange
    - _____Cation exchange resins
      - _____Sodium chloride, NaCl, regenerant used lbs per mg of filtered water
    - _____Lime-Soda
      - _____Lime $Ca(OH)_2$ used (lbs per mg)
      - _____Soda ash Na_2CO_3 used (lbs per mg)
- _____Iron and Manganese Removal
  - _____Sequestering agents (dosage in lbs per mg)
    - _____"Calgon", sodium hexametaphosphate
    - _____E. D. T. A.
  - _____Oxidation
    - _____Aeration
    - _____Chlorine Cl_2 (lbs per mg)
    - _____Ozone O_3 (lbs per mg)
  - _____pH Adjustment (dosage in lbs per mg)
    - _____Lime $Ca(OH)_2$
    - _____Soda Ash Na_2CO_3
    - _____Caustic soda NaOH
  - _____Ion-Exchange
    - _____Contact Filtration
      - _____Pyrolusite (manganese ore, MnO_2) filter

Table VI (Cont.)

- _____"Ripened Filters"
  - _____Conditioning chemicals (lbs per mg)
    - _____Ferric chloride $FeCl_3$
    - _____Lime $Ca(OH)_2$
- _____Contact Oxidation
  - _____Conditioning solutions (lbs per mg)
    - _____Manganous sulfate $MnSO_4$
    - _____Potassium permanganate $KMnO_4$
    - _____or Potassium chlorate $KClO_3$
    - _____or Sodium chlorate $NaClO_3$

_____Taste and Odor Control

- _____ Aeration
- _____Adsorbants
  - _____Activated carbon
    - _____Powdered
    - _____Granular filter bed
      - _____Volume of filter bed, cubic feet
      - _____Frequency of replacement
      - _____Quantity of water filtered between replacements
- _____Oxidants (dosage in lbs per mg)
  - _____Superchlorination Cl_2
    - _____Dechlorination
      - _____Sulfur dioxide SO_2

Table VI (Cont.)

    _____Sodium sulfite Na_2SO_3

    _____Sodium bisulfite $NaHSO_3$

    _____Activated carbon

_____Chlorine dioxide ClO_2

_____Potassium permanganate $KMnO_4$

_____Ozone O_3

Source: Rand, 1968

These values should be obtainable from records of the water utility. Call the total annual cost of water treatment DW.

e. Cost of Changing Supplies

Determine if a water utility has been forced to go to an alternate source of water supply due to degradation of the quality of the body of water under study. If so, determine the additional costs incurred by going to this alternate source. Include the costs of collection, treatment, and transmission and estimate the annual loss incurred by forced abandonment of the initial collection, treatment and transmission facilities. Include only that portion of the costs for the new facility which will provide a supply comparable in quantity and quality to the original supply prior to contamination. Call the cost of going to an alternate source AS.

2. Data Utilization for the Municipal Water

For the lake or stream under study, determine the annual municipal withdrawal water use benefits by directly summing the following values:

$$B(M) = DW + AS$$

where one or more municipalities actually use the water body as a source of supply. If the water body is not used as a source of supply but could be if it were not for degraded quality then the annual municipal withdrawal water use benefits may be estimated as:

$$B(M) = AS$$

B. Industrial Water Supply

1. Benefits to Industrial Water Users

In considering the damages incurred by industries using water of degraded quality Kneese (1968:9) has found that

> industrial costs turn out to be surprisingly insensitive to water quality within comparatively wide ranges - especially in regard to aspects of quality that are usually influenced by prior use and discharge of effluents. Sensitivity is greater to pollutants which in most cases are of natural origin, such as chlorides and magnesium. One important reason for the comparative insensitivity is that the vast proportion of industrial water use is for purposes that can readily accomodate low quality - cooling for instance. A second reason is that the really sensitive processes (high pressure boilers for example) ordinarily need water of such quality that extensive treatment is necessary if any kind of river water is used; water distinctly low quality can be used with only minor incremental costs. High pressure boiler

feed water must be distilled and the cost of distillation is not particularly sensitive to the quality of intake water. The moral of this is that not much pollution control can be justified by benefits to industrial users.

In order to determine the benefits which would accrue to industry with a decrease in water pollution it will be necessary to establish a profile of industrial water users close to the water resource, then determine the actual costs of water treatment and estimate the damages due to corrosion, scaling, and other effects.

The writers believe that only the costs of industrial water treatment necessary to produce a water of quality comparable to that produced by an adjoining municipal water utility should be included as withdrawal water use benefits. The reasoning here is that many industries require large quantities of ultra-pure process water. The production of this water involves costly distillation or demineralization and should be realistically assigned as a cost of preparing a raw material in a manufacturing process rather than as the cost of a normally supplied public utility.

2. Data Collection for the Industrial Water Use Survey

In order to tabulate the industrial water treatment costs and pollution-caused damages, the following data should be collected:

a. Locate all industries in the study area whose source of water supply is the water body under study.

b. Determine the total annual water usage and list the average and maximum daily usage of potable, process, cooling (both air conditioning and condenser) boiler feed and clean-up water.

c. Determine the extent of water treatment being practiced by completing the checklist shown in Table 16. Also include distillation, demineralization, and any other ultra-purification treatment processes.

d. Determine the annual cost of water treatment. Determine separate costs for separate supply streams if different degrees of treatment are provided. Where the treatment processes are similar to municipal treatment calculate the costs directly. Where the processes are special, but less costly than municipal water treatment, such as corrosion, scale and slime control, include these costs directly. Where ultra-purification processes are used include the costs for a municipal plant to supply a comparable quantity of water. Include in annual treatment costs, the costs of debt retirement, taxes, insurance, labor, maintenance, chemicals, power, and heating fuel.

These values should be obtained directly from industrial plants or a treatment cost index may be derived for each industrial use, and then total uses and costs projected from a sample of establishments.

Call the total annual cost of industrial water treatment IW.

e. Determine the annual corrosion, scaling, and other damages incurred by industries which may be attributed to degraded quality of the source and are not included in water treatment costs. These damage values may be considered negative benefits. Do this by direct questioning of the individual industries. Call this value ID.

3. Data Utilization for the Industrial Water Use Survey

For each water body under consideration in the study area determine the water quality benefits for industrial water use by summing as follows:

$$B(Q) = IW + ID$$

C. Agricultural and Farmstead Water Use Survey

1. Beneficial Agricultural and Farmstead Uses of Water

Water is used on individual farmsteads by the human farm population for drinking, food preparation, bathing, and laundry; for washing of fruits and vegetables in preparation for sale; in the production of marketable milk; for livestock watering and for irrigation of crops. Irrigation is the largest, single-purpose beneficial consumptive use of water in agriculture. About three-fourths of the water use in agriculture comes from surface supplies. Most individual farmstead supplies come from deep wells. Damages to uses include illness of livestock due to water-borne disease or excess minerals, crops suffering from high salinity of irrigation water, contamination of milk and food crops by polluted water rendering the produce unsaleable, and danger to the health of the farm family.

The Subcommittee for Agricultural Uses of the National Technical Advisory Committee on Water Quality (FWPCA, 1968:126) states that:

> Water for use by the human farm population, for washing and preparation of raw farm products for marketing, and for dairy sanitation should be potable as a minimum requirement.

The Interim Report of the National Technical Advisory Committee on Water Qaulity points out the economic importance of farm water quality.

> Effects of water quality deterioration or the impact of low quality supplies on agriculture are commonly insidious rather than dramatic. Even relatively small-scale changes may result in large economic consequences because of the shear size of the activity involved (FWPCA, 1967: Olive 5).

The Committee further states that:

> The raw water supply available to farmers must be of such

quality that it can be used in the raw state or be made acceptable for farmstead use with minimum treatment such as disinfection, filtration, and/or softening. Economic considerations alone will prohibit use of raw supplies that require extensive treatment to make them suitable for farmstead uses (FWPCA, 1967:Olive 23).

2. Data Collection for the Agricultural and farmstead water supplies may be difficult to estimate due to the difficulty of tracing ground water contamination. When considering a surface supply of water such as a lake or stream, the relationship between adjoining farm ground water supplies and pollution may be established somewhat easier. Where water is withdrawn directly from the surface supply estimation of damage is less difficult.

a. Determine if irrigation uses of water have been damaged or foregone by degraded water quality. If so, estimate the annual losses in value of crop production. Call this value CP.

b. Determine if poultry and livestock watering uses have been damaged or foregone by degraded water quality. If so, estimate the annual losses in value of production. Call this value LP.

c. Estimate the annual damages to farmstead water supplies caused by contamination of the initial supply and its relation to the surface source in question. Use the cost of developing an alternate supply such as going from a surface supply to a well supply in obtaining "city water", in drilling deeper wells, or in the purchase of home disinfection or filtration units. Call this value DS.

d. Determine the annual damages caused by microbial contamination to milk due to contaminated water. Use the market value of the milk which has been condemned. Call this value MK.

3. Data Utilization for the Agricultural and Farmstead Water Use Survey

For the water body in the study sum the agricultural and farmstead water use benefits as follows:

$$B(A) = CP + LP + DS + MK$$

D. Data Calculation for the Withdrawal Water Use Survey

Determine the total annual withdrawal water use benefits by summing the results of the municipal water survey, the industrial water use survey, and the agricultural and farmstead water use survey as follows:

$$B(WI) = B(M) + B(Q) + B(A)$$

Section VII
Waste Water Disposal Survey

Benefits of Municipal and Industrial Wastewater Disposal

The privilege to discharge an untreated or partially treated municipal or industrial wastewater effluent to a lake, stream or river which dilutes it and carries it away has a definite value to the waste dischargers. While the waste may create noxious problems for those water users downstream, the upstream discharger is rid of his waste at little cost and takes an "out-of-sight-out-of-mind" attitude.

Economists have defined as external diseconomies those costs which an industry has avoided by freely using a natural resource without payment. The free industrial use of the pollution-carrying capacity of a stream without consideration for other possible stream uses serves as one excellent example of an external diseconomy.

The federal and state governments have attempted to consider the needs of the downstream water user by setting quality standards for the stream as a whole or for the effluent which is discharged to the stream. The Ohio River Valley Water Sanitary Commission (ORSANCO) has established minimum conditions which are applicable to all waters at all places and at all times within their jurisdiction.

Smith (1968b) points out that the costs of wastewater treatment are highly dependent on the design capacity of the plant. Considering different degrees of waste treatment, a waste flow of 10 mgd (37,850 cubic meters per day) which would originate form an approximate population of 75,000 persons (130 gallons (492 l.) per capita per day) would cost $650 per day to treat with primary treatment, $1100 per day to treat with secondary activated sludge treatment, and approximately $1500 per day to treat with a form of tertiary treatment such as lime coagulation and sedimentation or sand filtration followed by chlorination.

Waste disposal benefits which accrue to the dischargers, both industrial and municipal, of untreated or partially treated wastewater may be estimated to be the total annual cost required to achieve waste treatment necessary to meet minimum stream or effluent standards. The cost between the existing level of treatment and the level of the minimum standard may be considered a present benefit to the discharger. The standards presently reflect the subjective hierarchy of beneficial water uses as determined by the governmental agency responsible for controlling pollution and thus may be used to estimate the importance of waste disposal with respect to other used.

Data Collection for the Wastewater Disposal Survey

In order to determine the benefits of wastewater disposal it will be necessary to determine the optimum quality standard for the stream or effluents to be discharged to the stream. The level of waste treatment for those wastes being discharged to the water body should be determined by collecting the following data:

1. Local Wasterwater Disposal Practices

Survey the basin tributary to the lake or stream being studied and locate municipal and idustrial wastewater outfalls. Determine the quantity of wastewater being discharged and describe its origin as sanitary sewage, industrial process water or cooling water. Describe the extent of wastewater treatment being practiced by completing the checklist shown in Table VII.

2. Costs for Additional Wastewater Treatment

Estimate the total annual costs for each municipal and industrial wastewater discharger so as to provide the essential additional wastewater treatment to meet minimum standards. For industrial wastewater treatment include the wastewater reduction techniques such as process changes, water reuse, counter-flow circulation of rinse water, timed sprays and quick shutoff valves. Include the cost of debt retirement, taxes, insurance, labor, maintenance, chemicals, power and heating fuel. Call this value WT.

3. Treatment to Remove Toxic Wastes

Identify any effluent sources which contribute highly toxic, high temperature, or radioactive materials to the lake or stream. Estimate the annual cost of treatment to completely remove these substances. Call this value TE.

4. Soil Conservation Costs

Determine the annual costs of soil conservation practices needed to prevent sheet erosion and consequent silting of streams and lakes. Call this value SC.

5. Costs for Interceptor Sewers

Determine the annual costs for interceptor sewers required to collect discharges from outfalls which presently discharge to receiving waters. Include costs of debt retirement, cleaning and maintenance costs, and pumping costs if the interceptor is a forced main. Obtain these estimated values from the managing utility. Call this value IS.

6. Costs of Water Quality Surveillance

Determine the annual costs of water quality surveillance required by regulating authorities to maintain standards. Include the costs of sampling and testing of waters, both manually and automatically, and the administrative and legal expenses incurred in enforcement proceedings. Obtain this information from local and state health departments, the U.S. Geological Survey and local sanitary districts. Call this value WQ.

7. Costs of Low Flow Augmentation

Determine if low flow augmentation is to be practiced on the stream. If so, estimate the annual costs of storage necessary to provide planned low flow releases. Call this value LF.

8. Costs of In-stream Aeration

Determine if in-stream aeration is to be practiced during periods of low flow. If so, determine the annual costs for equipment and operation. Call this value SA.

Table VII

Checklist of the Extent of Wastewater Treatment

Lake or River Reach ______________________________________

Municipality or Industry ______________________________________

Location ______________________________________

Outfall Location ______________________________________

Waste Flow (gallons (3.785 liters) per day)

Origin	Average	Maximum
Sanitary Sewage	______	______
Cooling Water	______	______
Process Water		
______________	______	______
______________	______	______
______________	______	______

Drainage Basin ______________________________________

Year Plant Constructed ______________________________________

Year Latest Major Improvements ______________________________________

Extent of Wastewater Treatment

_____None

_____Waste Treatment Units

    _____Preliminary Units

        _____Bar screen and screen chamber

        _____Comminutor

        _____Overflow and bypass chamber

        _____Grit chamber and washer

        _____Parshall flume flow measuring

Table VII (Cont.)

- _____Primary Units (20% to 40% BOD removal)
  - _____Plain settling
  - _____Settling tank with mechanical sludge collection
  - _____Imhoff tank
  - _____Lagoon
  - _____Septic tank
- _____Intermediate Units (40% to 70% BOD removal)
  - _____Chemical feed and flocculation
  - _____Modified aeration
  - _____Lagoon
- _____Secondary Units (70% to 90% BOD removal)
  - _____Standard rate trickling filter
  - _____High rate trickling filter
  - _____Super rate trickling filter
  - _____Two stage trickling filter
  - _____Activated sludge, conventional plug flow
  - _____Extended aeration activated sludge
  - _____Contact stabilization activated sludge
  - _____Sand filter
  - _____Lagoon
- _____Tertiary Units (greater than 90% BOD removal)
  - _____Sand filter
  - _____Lagoon
  - _____Chemical precipitation

Table VII (Cont.)

- _____Chlorination or Disinfection Units
  - _____Prechlorination
  - _____Post-chlorination
  - _____Ozone
  - _____Radiation
- _____Disposal of Liquids
  - _____Discharge to surface waters
  - _____Tile field to ground waters
  - _____Seepage pit or cesspool to ground waters
  - _____Sand filter to ground waters
  - _____Irrigation
- _____Sludge Handling Units
  - _____Preliminary Units
    - _____Holding
    - _____Thickening
    - _____Degritting
    - _____Chemical Addition
- _____Digestion Units
    - _____Anaerobic digestion (separate digestor)
    - _____Anaerobic digestion (Imhoff)
    - _____Wet oxidation (Zimmerman process)
    - _____Fluidized bed incineration
    - _____Chemical oxidation

Table VII (Cont.)

- _____Dewatering Units
    - _____Drying beds
    - _____Lagoons
    - _____Vacuum filtration
    - _____Centrifuge
    - _____Flash drying
- _____Disposal of Sludge
    - _____Burial, including sanitary land fill
    - _____Incineration
    - _____Barge to sea
    - _____To public as soil conditioner

C. Data Utilization for the Wastewater Disposal Survey

Let the wastewater disposal benefits be equal to the sum of the following items:

$$B(WD) = WT + TE + SC + IS + WQ + LF + SA$$

SECTION VIII

BORDERING LAND USE SURVEY

Water Quality Effects on Land Values

The value of property bordering a lake or a stream is definitely affected by the quality of water. This effect is most telling on riparian owners using the properties for recreation and residential purposes, but effects also extend to commercial, agricultural and industrial properties.

Nemerow (1966:21) has aptly expressed the relation between bordering property value and water quality.

> The public has learned through experience that water pollution can make their adjoining land less desirable and therefore lower in value. Elimination of obnoxious orors, hazardous swimming, and unsightly streams causes attractiveness which promotes increased property values; the local governments are able to assess these properties at a higher value and thus provide more tax revenues for the local river basin community. The increases in land values and tax revenues are direct benefits of waste treatment.

In determining the effect of water quality on the value of bordering property for a given use, the per acre market value of shoreline property should be compared with the per acre market value of near-by non-shoreline property. The difference in these per acre values reflects the unit benefits or damages of the shoreline location. Total benefits or damages may be calculated by multiplying the number of acres of shoreline property by the per acre benefits or damages. The inland non-shoreline property selected for comparison may be difficult to choose since it should be far enough removed from the water body to not reflect changes in value with changes in water quality, but it should be near enough to the water body to be considered competatively by a potential purchaser. It also should be located in the same taxation division as the shoreline property so that its value may be judged by the same real estate assessors.

Data Collection for the Bordering Land Use Survey

In order to measure the changes in property values due to water pollution it is suggested that the following information be gathered:

1. Real Estate Map

Obtain a small scale map of the area surrounding the lake or stream. A tax map of the area is the ideal map to be used but local real estate organizations or town, city or county public works

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department should also have satisfactory maps showing all streets and housing developments.

2. Tax Assessed Property Valuations

Consult local real estate property tax records, which are held by county or city governments. List all properties which border the lake or stream. This can usually be done since the tax records identify the boundary property with the lake or stream being a boundary line. Classify the property according to the system established by the local taxation authority. Table VIII shows the real property coding system prescribed by the New York State Board of Equilization and Assessment. Include the location of the property by street address, the character of the property according to the coding system, the linear dimensions of the property in feet, the number of acres contained in the parcel, the number of feet of shorelines frantage, the taxation division in which the property is located, the assessed unimproved or land value of the property and the assessed improved or full value of the property. List this data in a table similar in format to Table IX.

3. Comparison Assessed Values for Non-shorelines Property

Obtain from the tax records, information similar to that contained in Table IX for non-shoreline property removed from the lake or stream. Collect sample data for comparison on all property types which border the water body in each taxation division. Collect a sample of a size such that a valid comparison of assessed per acre values for shoreline and non-shoreline property may be made.

4. Equalization Rates

Determine the equalization rate for each taxation division in the study. The equalization rate in New York State is the ratio of the assessed value of real property to the full value of the property. The equalization rate for each town in the county is determined from an analysis of property sales in the town for the current year, by a County Tax Equalization Board which is composed of experienced property assessors. Tentative equalization rates are set by the state with the final rate being set by the County legislature or Board of Supervisors.

If, for a given town,

$$P/S = C$$

where P = the assessed value of property sold during the current year.

S = the sale price of property sold during the current year.

C = the equalization rate,

Table VIII

Classifications and Definitions of Types of Real Property

Code	Number	Property Description
F	10	FARM - Any rural parcel of land of more than 10 buildings, primarily used for agricultural purposes and not conforming with the definition of an estate.
R 1. R.	17	FARM, ABANDONED, or RURAL RESIDENCE - Include all farm properties with buildings on which farm operations have ceased and land is no longer used for farm purposes. This may include some rural residences with large acreage on which farm operations have ceased. If buildings constitute one-fourth or less of the value of the land classify as "rural land vacant (VL2)" or, as "Forest land", as the case may be.
Muck	19	MUCK FARMS - Any parcel of one acre or more, including appurtenant buildings, predominantly of the soil type, known as "Muck" which has been cleared and is now or has been recently under cultivation.
V. L. 2	15	RURAL VACANT LAND - Include all abandoned agricultural land, abandoned residential property, or wasteland in rural areas which is not devoted to agriculture or forests. Also include sand dunes, salt marshes, rocky areas and brush land of non-commercial tree species which are not associated with forest land.
R. 1.	21	ONE FAMILY RESIDENCE - Including individual trailers used for residences.
Est.	27	ESTATE - Property used primarily as a residence and containing at least five acres of land with a large and luxurious residence and auxilary buildings.
R. 2	22	TWO or THREE FAMILY RESIDENCE
Apt.	23	APARTMENT - Structures primarily used for residential purposes and containing at least four dwelling units.

Table VIII (Cont.)

Code	Number	Property Description
Cb	24	COMBINATION - Include buildings with retail stores and apartment which are located in residential areas.
VL 9	25	RESIDENTIAL LAND VACANT - Vacant lots or acreage located in residential areas.
Com.	40	COMMERCIAL (Over $50,000) - Business properties used primarily for retail stores, combination stores, and dwelling units in business districts; gasoline service stations, restaurants, clubs and bars, garages and automobile showrooms and other buildings used primarily for retail purpose.
Resort Recreational Property	48	SEASONAL RESORT or RECREATIONAL PROPERTY - Include and designate only properties which have accommodations for ten or more persons, such as resort hotels, summer boarding houses, skiing lodges, other commercial properties used primarily in connection with a seasonal resort and cabin or bungalow colonies used on a seasonal basis - unless the predominant use is in some other category, such as farms.
Ind.	52	INDUSTRIAL - Include all industrial and manufacturing establishments, warehouses and wholesale properties, grain elevators, cold storage plants, locker plants, coal years, oil company bulk plants, sand and gravel pits, and any other property with industrial characteristics. Do not include quarries, mines and oil and gas wells; also include all mills, feed mills, junk yards, milk processing plants, cheese factories, dry cleaning plants, laundries, newspaper printing plants, all storage buildings usually wholesale or manufacturing, bean elevators, grain elevators, any building where material is processed for wholesale distributors, asphalt and concrete plants.
V. L. 13	45	COMMERCIAL or INDUSTRIAL LAND VACANT - Vacant lots or acreage located in urban commercial or industrial areas.
Seas.	26	SEASONAL RESIDENCE - All seasonal residences such as camps, cottages, bungalows and other dwellings

Table VIII (Cont.)

Code	Number	Property Description
		subject to seasonal occupation. Do not include properties where the land contains forest land. (This will prevent some forest land from being included with camps or other seasonal parcels.)
Pri. For.	80	PRIVATELY OWNED FOREST LANDS - All lands of at least one acre bearing forest growth or that formerly bore forest growth and are not now put to some other use. Include all lands which are associated with forest land areas that have never conformed to any other classification nor have value because of commercial or industrial use. Examples are: rocky areas, blow-sand, wild grass along streams and flows, bruch of non-commercial tree species, also sugar-bushes not a part of a farm.
Pri. For.	81	PRIVATELY OWNED FOREST LANDS - Classified under Section 13 of the Tax Law. Include here any tract of forest or reforested land of 15 acres or more which has been approved by the Conservation Department of the State of New York for the purpose of classification for taxation of forest and reforested land. The Board of Equlization furnishes the assessor with exerpts from laws dealing with the assessment of real property including Section 13 of the Tax Law.
S.F.L.	90	STATE OWNED FOREST LAND - Include state owned forest land located in the Adirondack and Catskill forest preserves. Also include any other forest land owned by the State of New York.
O.S.L.	30	STATE OWNED LANDS - OTHER THAN FOREST - Include all state owned land other than forest lands.
C.F.L.	91	COUNTY OWNED FOREST LAND - Land purchased by a Board of Supervisors for the purpose of reforestation under section 219 of the County Law.

Table VIII (Cont.)

Code	Number	Property Description
C. F. B.	60	SPECIFY BY DESCRIPTIVE NAME (over $10,000)- All other parcels or property not covered by the foregoing authorized classifications shall be classified by descriptive name such as hotel, motel, trailer courts not operated on a seasonal basis, bank and office buildings, golf course, quarry, mines, piers, bulkhead, airport, fraternal organization buildings, private school, country clubs, drive-in theaters, amusement parks, baseball stadiums, libraries, museums, hospitals, or sanitariums, yacht clubs, theater, bowling alley, race tracks. Also parking lots, rooming houses, tourist homes, nursing homes, residence and office, billboards, commercial greenhouses, florists, and any miscellaneous buildings, such as barns or private garages, which would not be described by some other type of classification herein.
Ut.	70	UTILITIES - Include all public utility property, except special franchises. Any property subject to control of Public Service Commission, or Federal Power Commission, or Interstate Commerce Commission. Include oil, pressure and gas wells owned by Public Utility Company.
R. R.	71	RAILROADS - Include all property owned by railroads.

Source: New York State Board of Equalization and Assessment, 1962

Table IX

Assessed Property Values

Taxation Division (Town, City or County)______________ Year__________

Property Location Street Address	Character of Property Classification by Numerical Code	Linear Dimensions Feet (1)	Area in Acres (2)	Shoreline Frontage Feet	Assessed Unimproved or Land Value	Assessed Improved or Full Value

(1) One foot equals 0.3048 meters

(2) One acre equals 43,560 square feet, 4047 square meters or 0.4047 hectares.

Table X

1968 Equalization Rates for Onondaga County, New York

Town	Equalization Rate (1)
Camillus	0.22
Cicero	0.26
Clay	0.28
Dewitt	0.26
Elbridge	0.30
Fabius	0.32
Geddes	0.22
La Fayette	0.24
Lysander	0.26
Manlius	0.24
Marcellus	0.20
Onondaga	0.24
Otisco	0.31
Pompey	0.29
Salina	0.24
Skaneateles	0.28
Spafford	0.20
Tully	0.30
Van Buren	0.25
City of Syracuse	0.40

(1) Ratio of the assessed value to the full value of real property.

Source: Mulroy, 1967

and it is assumed that the town assessors were consistent in the relative valuations of property with no tendency to under or overvalue property owned by people living outside the area, then the full value of a given parcel or number of parcels of property may be estimated as:

$$S=P/C$$

Tendencies for town assessors to consistently undervalue or overvalue all property in town have been equalized by this method. Table X shows the 1968 equalization rates for Onondaga County, New York.

C. Data Utilization for the Bordering Land Use Survey

1. Property Value Benefits or Damages at Existing Quality

The bordering property value benefits for shoreline property at the existing quality may be estimated by successively calculating the differences in value of shoreline property and a corresponding number of shoreline property and a corresponding number of acres of non-shoreline property for each bordering land use. Table XI shows how this may be accomplished. The total assessed valuation of shoreline properties classified by the codes in Table VIII are listed in column (A). Column (B) contains the total assessed valuation of sample non-shoreline property of the same classification. Dividing (A) and (B) by the equalization rate in column (C) gives the total full valuation of shoreline and non-shoreline property in columns (D) and (E), respectively. Columns (F) and (G) give the number of acres of shoreline and non-shoreline property, respectively, which correspond to the total full values in columns (D) and (E). The value per acre of shoreline property is calculated in column (H) by dividing the total full value of shoreline property in column (D) by the total acres of shoreline property in column (F). Similarly, the value per acre of non-shoreline property is calculated in column (I). The ratio of the shoreline per acre property value to the non-shoreline per acre property value is formed in column (J). The shoreline property benefits for the given use, are calculated in column (K) as the number of acres of shoreline property (F) times the per acre value of non-shoreline property (I) times the quantity, the ratio of property values (J) minus one. The sign of the result in column (K) reflects benefits when it is positive and damages when it is negative.

The shoreline property benefits calculation in column (K) may be clarified by considering the contents of the columns as algebraic values. It may be seen that

$$K = F \times I\ (J-1) = F(H-I) = (F \times H) - (F \times I) = D - (F \times I)$$

where the value on the right hand side of the equation is the total

Table XI

Calculation of Shoreline Property Benefits

Character of property	Total Assessed Value of Shoreline Property A	Total Assessed Value of Sample Non-Shoreline Property B	Equalization Rate Decimal Fraction C	Total Full Value of Shore-Line Property D=A/C	Total Full Value of Sample Non-Shoreline Property E=B/C	Number of Acres of Shoreline Property F	Number of Acres of Sample Non-Shoreline Property G	Value Per Acre of Shoreline Property H=D/F	Value Per Acre of Sample Non-Shoreline Property I=E/G	Ratio of Shoreline Value Per Acre to Non-shore line value Per Acre J=H/I	Bordering Property Benefits (+) or Damages (-) K= FxI(J-I)

full value of shoreline property (D) less the value of a corresponding number of acres of non-shoreline property, (F) times (I); which is the assumed definition of bordering property value benefits.

The total bordering property value benefits, B(LT), may be calculated by taking the algebraic sum of column (K), that is, by adding positive values and subtracting negative values.

2. Bordering Property Value Benefits at a New Water Quality

The ratio of the shoreline per acre property value to the non-shoreline per acre property value may be calculated for a second body of water at a new water quality for each use classification at the original water body. It may be assumed that, if the original water body achieved the new water quality, the ratio, (J) would be identical with that of the second water body for the given use. Tabulating these new ratios and applying them in column (K) of Table XI will allow the estimation of total bordering property value benefits, B (LT), at a new water quality.

3. Annual Bordering Property Value Benefits

It should be noted that the property value benefits are the only benefits not estimated directly on an annual basis. The benefits are considered as non-reoccuring, in that, for a given water quality, the gross effect on shoreline property values may be listed only once. When combining these benefits with the other annual benefits it will be necessary to place them on an annual basis by dividing the value, B(LT), by a specific time period in years to produce annual bordering property value benefits, B(L). The time interval may be related to the time required to produce measurable change in water quality following the installation of a waste treatment plant.

SECTION IX

IN-STREAM WATER USE SURVEY

Water Quality Effects on Other In-Stream Water Uses

Other in-stream water uses include commercial fishing, barge and ship navigation, flood control and hydroelectric power generation.

The value of damages to navigation by degradation of water quality may vary greatly in comparison to other uses. Extreme pollution of navigable waterways may create many problems. The deposition of sludge banks in navigation channels requires expensive dredging to keep them open to traffic. Floating debris may damage ship and barge hulls and propellers, and clog engine cooling systems. This debris may also damage navigation control structures by jamming submerged conduits and mechanisms and requiring expensive techniques for removal and repair. Floating oil and grease coats hulls and structures with black, gummy deposits which are unsightly and increase hydraulic friction. These inflammables also present a danger of catching fire on the water surface. Corrosion damages occur to ship and boat hulls and navigation control structures due to low quality water.

Damages generated by flooding with low quality water may be of great significance in cases where difficult to remove residues are deposited or water supplies are polluted.

Water quality damages to flood control and hydroelectric power structures should be confined mainly to corrosion of metal parts, silting of reservoirs, blockage of intake channels by floating debris and loss of hydraulic capacity due to biological growths.

Data Collection for the In-stream Water Use Survey

1. Commercial Fishing Benefits

Determine the total annual value of commercially caught fish taken from the water body under consideration. Call this value CF.

2. Navigation Damages

Estimate the annual water quality damages to navigation include:

a. The cost of maintenance dredging of sludge banks from navigation channels.

b. The corrosion damage costs to ship and boat hulls and engine cooling systems.

c. The cost of corrosion to navigation control structures such as locks, dams and conduits.

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d. The cost of loss of hydraulic capacity, increased friction and damage to hulls caused by infestations of slimes, worms, barnacles and other growth living on nutrients in the water. In some cases biological growth may increase with increased water quality. Call the total annual water quality damages to navigation ND.

3. Flood Damages

Estimate the annual water quality damages related to flooding. Include the following:

a. The cost of increased reservoir storage capacity required to decrease the probability of flooding with low quality water.

b. The value of corrosion damages to reservoirs, control structures, conduits and equipment.

c. The value of damages of decreased hydraulic capacity through the silting of reservoirs, blockage of intake channels, and loss of reservoir capacity caused by floating debris.

Call the annual water quality damages related to flooding FC.

4. Hydroelectric Power Generating Damages

Estimate the annual damages to hydroelectric power generating facilities due to depressed water quality. Include:

a. The generating plant damages due to erosion of turbines and conduits.

b. The damages of decreased hydraulic capacity through the silting of reservoirs, blockage of intake channels, and loss of reservoir capacity caused by floating debris.

Call the hydroelectric power generating damages HP.

Data Utilization for the In-Stream Water Use Survey

1. Annual In-stream Water Use Benefits at Existing Quality

Determine the total annual in-stream water use benefits by summing as follows:

$$B(IS) = CF - ND - FC - HP$$

Note that the algebraic sign of those values which are damages is taken as negative. That is, a damage is considered a negative benefit.

2. Annual In-Stream Water Use Benefits at a New Water Quality

d. The cost of loss of hydraulic capacity, increased friction and damage to hulls caused by infestations of slimes, worms, barnacles and other growth living on nutrients in the water. In some cases biological growth may increase with increased water quality. Call the total annual water quality damages to navigation ND.

3. Flood Damages

Estimate the annual water quality damages related to flooding. Include the following:

a. The cost of increased reservoir storage capacity required to decrease the probability of flooding with low quality water.

b. The value of corrosion damages to reservoirs, control structures, conduits and equipment.

c. The value of damages of decreased hydraulic capacity through the silting of reservoirs, blockage of intake channels, and loss of reservoir capacity caused by floating debris.

Call the annual water quality damages related to flooding FC.

4. Hydroelectric Power Generating Damages

Estimate the annual damages to hydroelectric power generating facilities due to depressed water quality. Include:

a. The generating plant damages due to erosion of turbines and conduits.

b. The damages of decreased hydraulic capacity through the silting of reservoirs, blockage of intake channels, and loss of reservoir capacity caused by floating debris.

Call the hydroelectric power generating damages HP.

Data Utilization for the In-Stream Water Use Survey

1. Annual In-stream Water Use Benefits at Existing Quality

Determine the total annual in-stream water use benefits by summing as follows:

$$B(IS) = CF - ND - FC - HP$$

Note that the algebraic sign of those values which are damages is taken as negative. That is, a damage is considered a negative benefit.

2. Annual In-Stream Water Use Benefits at a New Water Quality

Determination of annual in-stream water use benefits at a new water quality involves the estimation of the increased value of commercial fishing, CF and the decrease in the navigation damages, ND, the flood related damages, HP. The new in-stream use benefits B(IS) then may be determined by summing as before.

SECTION X

MEASUREMENT OF THE TOTAL DOLLAR BENEFIT OF WATER POLLUTION CONTROL-AN EXAMPLE-ONONDAGA LAKE, ONONDAGA COUNTY, NEW YORK

In this section the procedure for measurement of the total dollar benefit of water pollution control which has been presented in the previous chapters is applied in an abbreviated form to Onondaga Lake.

Location and Description of Onondaga Lake

Onondaga Lake is located in central New York State just north of the center of Onondaga County and immediately northwest of the City of Syracuse, as shown in Figure 2. Geographically, the lake lies in the Limestone Belt which trends east-west and is bounded on the south by the highlands of the Northern Appalachian Plateau and on the north by the rolling topography of the Ontario Lake Plain (Berg, 1963).

Onondaga Lake is roughly rectangular in shape with its long axis running from southeast to northwest. It has an average width of approximately one mile and is about 4.5 miles long. The lake is generally very deep with an average depth of 42 feet and large areas from 50 to 75 feet deep (Onondaga Lake Scientific Council, 1966: 16).

Onondaga Lake has a surface area of four square miles of 2560 acres, drains a basin of a total of 241 square miles and is part of the Oswego River drainage basin (New York State Department of Health, 1951).

The outlet of the lake is through a one mile long channel discharging into the Seneca River, which flows northerly and unites with the Oneida River to form the Oswego River. The Oswego River ultimately discharges into Lake Ontario at the City of Oswego, (Onondaga Lake Scientific Council, 1966:16), some forty miles north of Syracuse.

The major tributaries of Onondaga Lake are Ley Creek, Onondaga Creek, Harbor Brook, and Ninemile Creek. The Ley Creek watershed extends generally east from Onondaga Lake and has an area of 26.16 square miles with a total length of the main stream of 9.5 miles. The Onondaga Creek watershed extends south from the southern end of Onondaga Lake and has an area of 102.46 square miles with a total length of mainstream of 27.5 miles. The Harbor Brook watershed extends to the south and slightly west from the southern end of Onondaga Lake and has an area of 13.22 square miles with a total stream length of 7.5 miles. The Ninemile Creek watershed extends west and south

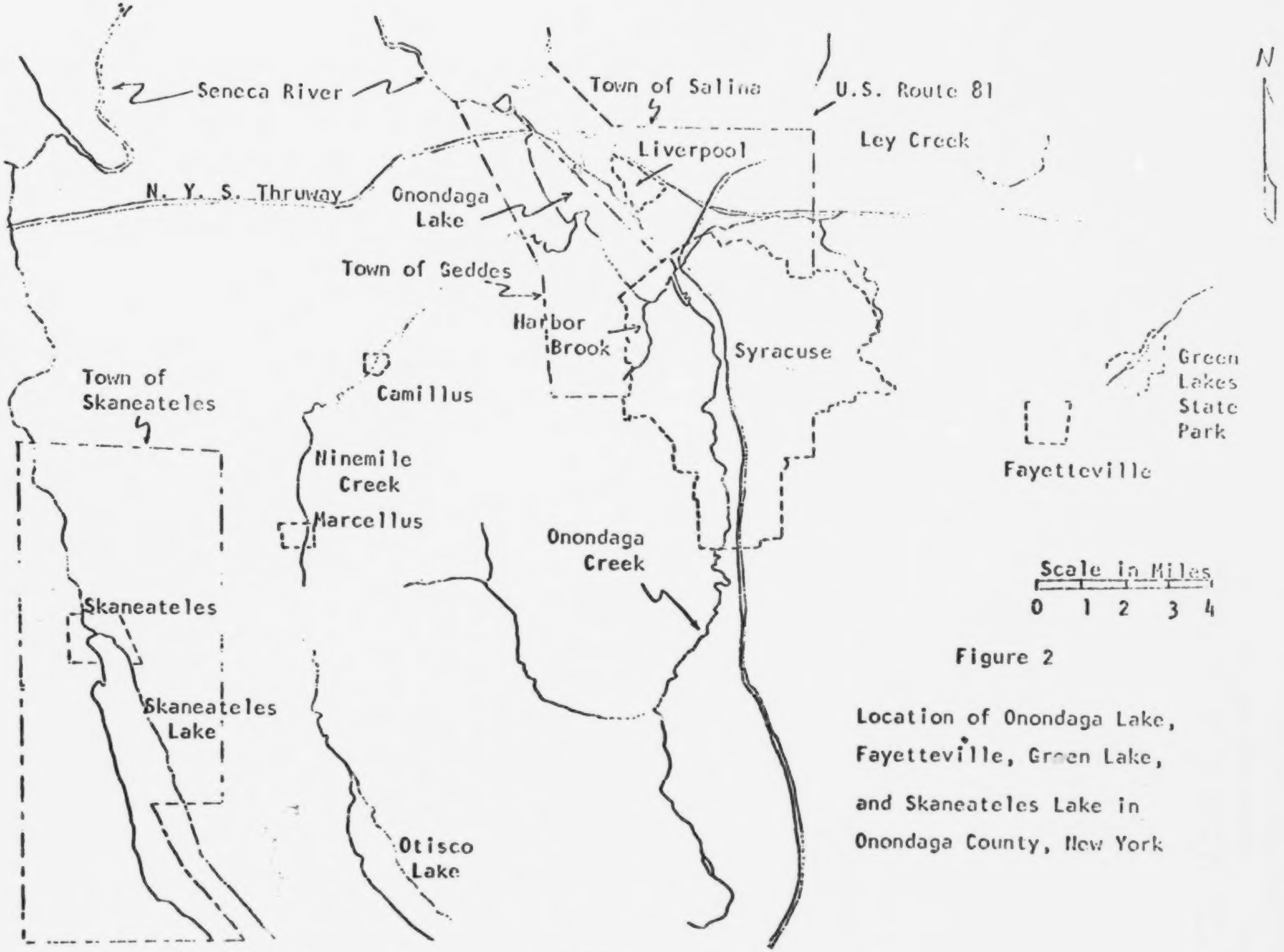
N
Seneca River
Town of Salina
U.S. Route 81
Ley Creek
Liverpool
N. Y. S. Thruway
Onondaga Lake
Town of Geddes
Harbor Brook
Syracuse
Green Lakes State Park
Town of Skaneateles
Camillus
Fayetteville
Ninemile Creek
Marcellus
Onondaga Creek
Scale in Miles
0 1 2 3 4
Skaneateles
Skaneateles Lake
Otisco Lake

Figure 2

Location of Onondaga Lake, Fayetteville, Green Lake, and Skaneateles Lake in Onondaga County, New York

Source: Onondaga County Department of Public Works, 1964.

from the western shore of Onondaga Lake and has an area of 90.85 square miles, with a total length of main stream of 34.3 miles (New York State Department of Health, 1951.) Included in this watershed at the headwaters of Ninemile Creek is Otisco Lake with a watershed area of 34 square miles and a surface area of 3.47 square miles.

As a part of the New York State Barge Canal System, the water surface elevation of Onondaga Lake is controlled by a dam on the Oswego River at Phoenix, New York just north of the confluence of the Seneca and Oneida Rivers. The low water elevation is 363 feet referenced to Barge Canal datum. The maximum level of the lake occurred in 1936 when a flood level of 371.6 feet was recorded (Milovicz, 1968). This is about eight feet of available flood storage and thus gives approximately 20,480 acre-feet of water storage capacity.

Characteristics of Bordering Lands

The property bordering Onondaga Lake may be generally divided into four distinct segments and classified by present land uses as shown in Figure 3. Segment #1 may be considered as Onondaga Lake Park, which extends from the Syracuse City line at Part Street, near the Liverpool exit of U.S. Route 81, along the northeast shore to the Lake outlet. Segment #2 may be considered as the West Shore Park extending from the lake outlet at Maple Bay to the mouth of Ninemile Creek to the Syracuse city line just south of the Allied Chemical Corporation docks at State Fair Boulevard. Segment #4 may be considered as the area located predominantly at the southern end of the lake in the City of Syracuse. The Syracuse city line cuts the bottom of the lake at the southeast and extends from Park Street at the Will and Baumer Candle Company to State Fair Boulevard, just south of the Allied Chemical Corporation docks.

Most of the land immediately bordering Onondaga Lake is government-owned, either by Onondaga County or New York State. This reflects the original flood storage use of the lake. The Onondaga County Division of Parks and Conservation administers Onondaga Lake Park and the West Shore Park in Segments #1 and #2 respectively.

Onondaga Lake Park runs six miles along the northeastern shore of the lake and around its northwestern end to the Long Branch Picnic Area, which lies across the lake outlet from the Willow Bay and Mud Lock Picnic areas (Onondaga County Department of Public Works, 1967).

A scenic parkway extends along about half of the northeast shoreline of the lake through Onondaga Lake Park, connecting the City of Syracuse with the park entrance and the Village of Liverpool (Onondaga Lake Scientific Council, 1966).

The West Shore Park is presently not open to the public and work is in progress to reclaim the low-lying swampy area for park use.

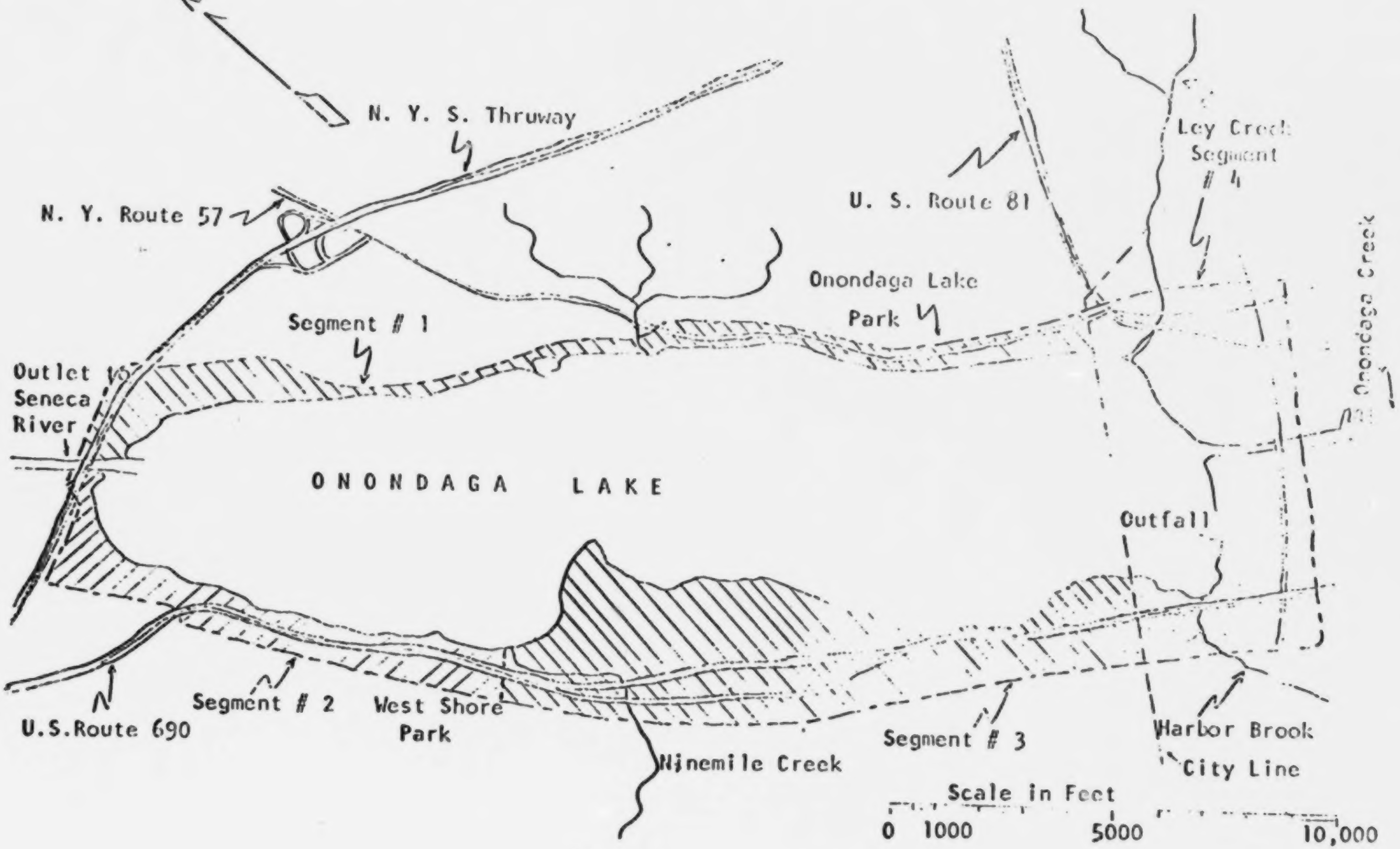
N
N. Y. S. Thruway
N. Y. Route 57
U. S. Route 81
Ley Creek
Segment
# 4
Onondaga Creek
Onondaga Lake
Park
Segment # 1
Outlet
Seneca
River
ONONDAGA LAKE
Outfall
U.S.Route 690
Segment # 2
West Shore
Park
Ninemile Creek
Segment # 3
Harbor Brook
City Line
Scale in Feet
0 1000 5000 10,000

Figure 3
Characteristics of Land Bordering Onondaga Lake

Source: Onondaga Lake Scientific Council 1966.

> Since September of 1966, Onondaga County and Solvay Process (Division of Allied Chemical Corporation) have been building dikes for thirteen basins and filling basins with sludge that is being dredged from Onondaga Lake (Journal of the Board of Supervisors, Onondaga County, 1967: 621).
>
> The delta which had formed at the mouth of Ninemile Creek will be removed by these operations... At the present time approximately fifty percent of the required dredging is completed and we are approximately one year ahead of schedule on the program (Hennigan, 1968: 6).

Bordering both Onondaga Lake Park and the West Shore Park are residential areas in the towns of Salina and Geddes respectively.

New York State owns most of the lakeshore property in Segment #3. Adjoining these lakeshore lands, on the lakeside of U.S. Route 690, are waste beds of the Allied Chemical Corporation having an elevation of about seventy feet above the lake surface. A portion of these beds has been purchased by New York State as parking lot areas for the New York State Fairgrounds which is located south of Route 690. Further southeastward are a Crucible Steel Corporation parking lot and Allied Chemical Corporation wharf facilities.

The Segment #4 area at the southeast end of the lake contains industrial and commercial properties. These lakeshore lands include the Syracuse Barge Canal Terminal, tank farms for the storage of petroleum products, the Onondaga County Metropolitan Waste Treatment Plant, the Niagara-Mohawk Power Corporation natural gas distribution, a scrap metal yard, and a Penn-Central Railroad right-of-way.

The Existing Water Pollution Problem

The Federal Water Pollution Control Administration (FWPCA, 1966b) reports that Onondaga Lake is the most grossly polluted lake in the entire Lake Ontario Basin.

Hennigan (1968a:1) lists the four major problems affecting Onondaga Lake as:

1. The sewage plant effluents entering the lake and its tributaries.
2. The wet-weather over-flows from Onondaga Creek and Harbor Brook intercepting sewers.
3. Industrial wastes produced on the watershed.
4. Organic deposits on or immediately above the lake bottom in a state of anaerobic decomposition.

Sewage plant effluents now entering the lake include approximately forty million gallons per day from the Metropolitan Waste Treatment

Plant which have received the intermediate treatment of chemically-aided settling; ten million gallons per day from the Ley Creek Treatment Plant where the treatment consists of an overloaded biological process; and lesser quantities from the Villages of Camillus and Marcellus on the Ninemile Creek watershed.

The Onondaga Creek and Harbor Brook intercepting sewers and designed to carry only twice the dry weather flow and during storms the excess flow is spilled from sixty-nine overflow points into Onondaga Creek and Harbor Brook.

> These overflows, although they occur only two to three percent of the time are, in our opinion, a major source of pollution of the lake, since the untreated discharges are as much as ten times as a strong as ordinary domestic sewage (Hennigan, 1968a:2).

The main contributors of industrial wastes to Onondaga Lake are those industries tributary to Ley Creek and those which border the lake on the east and southwest. On the southwest, the Industrial Chemicals Division of Allied Chemical Corporation discharges considerable amounts of inorganic solids in its process effluents, 100 mgd of heated cooling water and sanitary wastes. The Crucible Steel Corporation discharges 5.5 mgd of metal - bearing wastes to the lake. On Ley Creek and the east shore of the lake are over 100 industries producing wet wastes.

The organic bottom deposits in Onondaga Lake are the result of close to a century of discharge of waterborne wastes from the homes, businesses and industries of Syracuse. This organic sludge has accumulated to "estimated depths of twelve feet in some areas (Onondaga Lake Scientific Council, 1966:19)." Until 1925 the untreated wastes of the City of Syracuse were discharged into Onondaga Lake via Onondaga Creek, Harbor Brook or an outfall sewer. From 1925 to 1960, with some periods of interruption, these wastes have received intermediate treatment at the Metropolitan Waste Treatment Plant (Onondaga Lake Scientific Council, 1966).

Measurement of Recreation Use Benefits

All of the present water-oriented recreation uses of Onondaga Lake are related to activities occurring at Onondaga Lake Park. The benefits of recreation uses at Onondaga lake Park are estimated at existing water quality. Green Lake State Park at Fayetteville, New York, located approximately fifteen miles east of Onondaga Lake Park was chosen for an interspatial comparison to estimate the value of Onondaga Lake at a higher water quality. Green Lake surface water is of relatively high quality when compared to that of Onondaga Lake and the lake supports a large amount of swimming and some boating. Fishing benefits at higher water quality are estimated by an intertemporal study of fishing demand.

Table XII

Recreation Benefits of Onondaga Lake at Existing Water Quality

(1) J	(2)	(3) D(J)	(4) P(J)	(5) V(J)	(6) A(J)	(7) T(J)	(8) C(J)	(9) V(J)x C(J)	(10) $\frac{V(J)}{P(J)}$
1	0-2	1	*87,234	45,912	0	.20	.84	38,566	.526
2	2-4	3	*103,438	55,504	0	.60	1.24	68,825	.537
3	4-6	5	*132,895	63,280	0	1.00	1.64	103,779	.476
4	6-10	8	*78,563	79,676	0	1.60	2.24	178,474	1.014
5	10-15	12.5	52,886	43,315	0	2.50	3.14	136,009	.819
6	15-20	17.5	49,936	34,844	0	3.50	4.14	144,254	.698
7	20-25	22.5	76,189	11,091	0	4.50	5.14	57,008	.146
8	25-30	27.5	73,803	10,061	0	5.50	6.14	61,775	.136
9	30-40	35	157,994	9,719	0	7.00	7.64	74,253	.062
10	40-50	45	261,490	12,804	.50	9.50	10.64	136,235	.049
11	50-150	100	5,268,207	17,960	1.00	21.00	22.64	406,614	.00341
			Total Visits	V=384,166	Annual Recreation Benefits =			1,405,792	

(1) Zone number (2) Mileage range of zone margins. (3) One way distance from park to center of zone, in miles, (4) 1960 (*1967) population of each zone by individuals. (5) Annual attendance from each zone in visits. (6) Estimated travel associated cost per visit from each zone in dollars. (7) Travel cost in dollars per visit to visitors from zone J, K = 10 cents per mile. (8) Total cost per visit in dollars to visitors from zone J. (9) Annual recreation benefits in dollars. (10) Unit recreation demand.

Table XIII

Onondaga Lake Annual Attendance for Water-Related Activities

Use	Visits			Percent of Total Use (5)
	1966	1967	1966-1967 Average (4)	
Picnic Areas				
Willow Bay	60,276	85,595	72,935	
Mud Lock, Cold Springs	51,933	33,361	42,647	
Long Branch	33,993	33,334	33,633	
Hiawatha Point	56,405	73,850	65,127	
Off Highway	122,178	65,698	93,938	
Picnic Subtotal			308,310	80.2
Girl Scout Day Camp Area	37,927	31,892	34,909	9.1
National Rowing Association Regatta	27,900	22,500	25,200	6.6
Yacht Basin (Marina)	15,245	16,250	15,747	4.1
Total	405,857	362,480	384,166	100.0

Source: Shattuck, 1968 a:16

1. Travel Distance Zones of Visitor Origin

Eleven concentric mileage zones of visitor origin are delineated for Onondaga Lake with zone numbers (J) and mileage ranges as shown in columns (1) and (2) respectively of Table XII. The average one way distance in miles from the center of each zone D (J), is listed in column (3). For example, J equals zone 3 for a concentric circular areas with boundaries having radii of 4 and 6 miles and with an average one way distance from the center of the zone D(3) equal to 5 miles. Zone number 11 is assumed to have a travel distance range of 50 to 150 miles with a A(11) of 100 miles. Similar zones and distances are determined for Green Lake.

2. Population Determination of Each Zone

The population P(J) of each zone of origin (J) for Onondaga Lake is listed in column (4) of Table XII. The population is determined by using a federal government census map having townships and villages plainly marked. Concentric circles were drawn about the main park entrance having radii equal to the mileasges in column (2). The population of a village or town is distributed to given zones in proportion to the percent of total village or town land area in that zone. For example, the Town of Camillus, less the Village of Camillus is found to have a 1967 population of 34,069. It is estimated that 20 percent of the total town land area falls in zone number 2 and 40 percent each in zone numbers 3 and 4. The population is thus distributed as follows: 6,813, (calculated from 0.20 x 34,069) to zone number 2 and 13.628, (calculated from 0.40 x 34,069) to zone numbers 3 and 4. The population of each zone is then determined by summing the distributed amounts from each village and town. For example, the zone 3, (1967 census) population is computed to be 132,895. Similar calculations are made for Green Lakes State Park, as shown in Table XVIII.

3. Annual Recreation Attendance

The 1966 - 1967 average annual attendance for water-related activities at Onondaga Lake Park totaled 384,166 and is shown in Table XIII. It should be noted that the 1966 - 1967 average total attendance was 700,453 with the more than 300,000 additional visits to the French Fort and Salt Museum historic sites and to watch and participate in atheletic events held at Griffin Field (Shattuck, 1968a). These additional visits were for non-water-oriented recreation and are not considered in the benefit analysis. Let the total annual visits (V) equal 384,166. Annual attendance for water-oriented recreation at Green Lakes State Park was 451,213 (Holden, 1967).

The origin, by county, of a sample of visitors to both Onondaga Lake Park and Green Lakes State Park is determined by a license plate survey taken of cars parked in the parking lots during six days in August, 1968 as shown in Table XIV. It is assumed that

Table XIV

License Plate Survey* of the Origin of Visitors to Onondaga Lake Park and Green Lakes State Park

County of Origin	Onondaga Lake Park		Green Lakes State Park	
	Sample Size (Cars)	Percent of Total	Sample Size (Cars)	Percent of Total
Onondaga	2426	65.93	3732	54.64
Oneida	158	4.30	944	13.82
Madison	49	1.34	452	6.62
Oswego	124	3.36	335	4.90
Cortland	35	.96	109	1.59
Cayuga	59	1.61	98	1.43
Wayne	48	1.32	102	1.50
Monroe	42	1.14	217	3.18
Seneca	21	.57		
Chenango			97	1.42
Tompkins	15	.41	33	.48
Broome	17	.45	96	1.40
Out of State	386	10.50	382	5.60
Others	298	8.11	234	3.42
Total	3680	100.00	6831	100.00

*The survey was conducted on the following dates, August, 3, 4, 6, 8, 11 and 13, 1968 which were three weekends and three weekdays.

Source: Yopps, 1968:119

Table XV

Attendance Distribution by Zone at Onondaga Lake Park and Green Lakes State Park

	Attendance Distribution (in percent of total)		Estimated 1966-1967 Average Attendance From Each Zone in Visits V(J) = % x V	
Zone Number	Onondaga Lake	Green Lakes	Onondaga Lake	Green Lakes
1	11.95	2.15	45,912	9,688
2	14.45	3.24	55,504	14,606
3	16.47	1.19	63,280	5,356
4	20.74	20.63	79,676	93,103
	11.28	23.51	43,315	106,095
6	9.07	9.36	34,844	42,215
7	2.89	5.44	11,091	24,555
8	2.62	5.59	10.061	25,218
9	2.53	15.88	9,719	71,666
10	3.33	1.97	12,804	8,911
11	4.67	11.04	17,960	49,800
Total	100	100	384,166	451,213

Table XVI

Weighted Average Base Cost per Visit for Water-Oriented Recreation

Uses at Onondaga Lake Park and Green Lakes State Park

Recreation Uses	Onondaga Lake Park			Green Lakes State Park		
	Ratio of Specific Recreation Use to Total Park Use A	Estimated Specific Base Cost per Visit Dollars B	Weighting Factor Product A x B = C	Ratio of Specific Recreation Use to Total Park Use D	Estimated Specific Base Cost per Visit Dollars E	Weighting Factor Product D x 3 = F
Sightseeing (NRA Regatta)	.066	1.00	.066			
Swimming				.551	0.75	.413
Picnicking	.802	0.50	.401	.362	0.50	.398
Boating (Onondaga Yacht Basin, Green Lake rowboats)	.041	3.00	.123	.032	0.50	.016
Camping (Day Camps)	.091	0.50	.046	.055	0.50	.028
Weighted Average Base Cost per Visit R =			.636 = $0.64			R = .855 = $0.86

Table XVII

Travel Associated Costs per Visit

Zone Number	One way Distance D(J)	Food Costs Above At-home Costs B Dollars	Hotel and Motel Costs $10.00 person / day C Dollars	Tourist Goods & Services D	Travel Associated Costs A(J) = 2(b) + C+D Dollars
1	1	0	0	0	0
2	3	0	0	0	0
3	5	0	0	0	0
4	8	0	0	0	0
5	12.5	0	0	0	0
6	17.5	0	0	0	0
7	22.5	0	0	0	0
8	27.5	0	0	0	0
9	35	0	0	0	0
10	45	.25	0	0	.50
11	100	.25	0	.25	1.00

this sample is representative of those visitors participating in water-oriented recreation even though the sample includes visitors to the historic sites and atheletic fields.

The percentage distribution of visitors by county is further distributed to towns within a county in direct proportion to the ratio of the town population to the county population. These values are distributed to each zone in direct proportion to the percent of total town land area in that zone. Table XV shows the attendance distribution by zone for Onondaga Lake Park and Green Lakes State Park. For example, for Onondaga Lake Park, of the total visitors (V equals 384,166) to the Park, 63,280 (V(3) equals 16.47% of 384,166) are estimated to have come from zone 3.

4. Average Recreation Participation per Visit by Use and Zone

A survey by direct questioning of the recreation users of Onondaga Lake Park was not conducted therefore it is assumed that the participation rates N(I,J), for picnicking, boating, day camping and Regatta sightseeing are all equal to one (I) visitor-day per visit, for visitors from all zones.

5. Base Cost per Visit for Each Use

A weighted average base cost per visit, (R), for all water-oriented recreation uses is estimated to be $0.64 per visit at Onondaga Lake Park and $0.86 per visit at Green Lakes State Park as shown in Table XVI. The specific base costs per visit for each recreation use are estimated as $0.75 for swimming (Crites, 1966:52; Heniey, 1967:438; Koenings, 1968:1); $3.00 for motor boating on Onondaga Lake (Crites, 1966:49; Kneese, 1968:11); $0.50 for row boating on Green Lake (Holden, 1967); $0.50 for picnicking (Crites, 1966:59); $0.50 for childrens' day camps; and $1.00 for sightseeing by spectators at the National Rowing Association. Regatta on Onondaga Lake.

6. Automobile Travel Costs

Automobile travel costs (K) are estimated to be equal to $0.10 per mile.

7. Travel Associated Costs Per Visit

Travel associated costs, listed in Table XVII, are estimated to be composed of the costs of food over at-home costs, hotel and motel expenses and costs for tourist goods and services.

Excess food costs are estimated to be $0.75 for breakfast, $1.25 for lunch and $2.00 for dinner, totaling to an additional for $4.00 per day spent by an individual for food while traveling over that spent at home.

Overnight accomodations are estimated to be required for trips greater than 300 miles and hotel or motel costs are estimated to be $10.00 per adult per night.

An individual is assumed to spend $1.00 per day for tourist goods and services while traveling.

For example, travel associated costs A(3), to a visitor from zone 3 are estimated to be zero (0) while a visitor from zone 11 paid A(11) equals $1.00.

8. Travel Costs per Visit

Travel costs per visit T(J) to visitors from each zone (J) are equal to twice the average cost per mile for automobile travel (K) times the average one way distance in miles from the center of the zone D(J) plus the travel associated cost per visit to visitors from each zone A(J) and are calculated in column (7) of Table XII as:

$$T(J) = 2 \times K \times D(J) \times A(J) \qquad (1)$$

9. Total Cost per Visit for Each Zone

The total cost per visit C(J) to visitors from each zone (J) is equal to the weighted average base cost per visit (R) plus travel costs per visit T(J) divided by the participation rate N(I,J) in visitor-days per visit and is calculated in column (8) of Table XII as:

$$C(J) = \frac{R + T(J)}{N(I,J)} \qquad (2)$$

Annual recreation benefits are calculated for each zone (J) in column (9) of Table XII.

The annual additional cost of park maintenance and operation G(I) for Onondaga Lake Park in 1967 is estimated to be equal to $73,624. This is the difference between an estimated 15 percent of the 1967 Onondaga County Department of Parks and Conservation budget or $87,942 for park expenditures and $14,318 in reimbursements received at Onondaga Lake Park for the rental of boat slips, picnic and outing reservations, concession stand leases, state aid to recreation and other miscellaneous income (Journal of the Board of Supervisors, Onondaga County, 1967; Shattuck, 1968a).

Total annual recreation use benefits at Onondaga Lake Park at existing water quality are obtained by summing column (9) in Table XII and the addition of G(I) as follows:

$$[\ B(R)]\ (1) = \sum_{j=1}^{11} V(J) \times C(J) + G(I) = \$1,405,792 + \$73,624 = \$1,479,416 \qquad (3)$$

Table XVIII

Unit Recreation Demand for Green Lakes State Park, Fayetteville, New York

Zone Number J (1)	Mileage Range (2)	One Way Distance Miles D(J) (3)	(1960) (*1967) Population of Each Zone Persons P(J) (4)	Average 1966-1967 Annual Attendance from Each Zone Visits V(J) (5)	Unit Recreaction Demand Visits per V(J)/P(J) (6)
1	0-2	1	15,875	9,688	0.610
2	2-4	3	24,574	14,606	0.594
3	4-6	5	*23,537	5,356	0.228
4	6-10	8	*160,037	93,103	0.582
5	10-15	12.5	*198,148	106,095	0.535
6	15-20	17.5	*74,391	42,215	0.567
7	20-25	22.5	*58,960	24,555	0.416
8	25-30	27.5	90,082	25,218	0.280
9	30-40	35	323,174	71,666	0.222
10	40-50	45	81,511	8,911	0.109
11	50-150	100	5,268,207	49,800	0.00946
			Total Visits V =	451,213	

Table XIX

Recreation Benefits of Onondaga Lake at Green Lake Water Quality

(1)	(2)	(3) D(J)	(4) $\frac{V(J)}{P(J)}$	(5) P(J)	(6) V(J)	(7) A(J)	(8) T(J)	(9) C(J)	(10) V(J)x C(J)
1	0-2	1	.794	*87,234	69,264	0	.20	1.06	73,420
2	2-4	3	.811	*103,438	83,888	0	.60	1.46	122,476
3	4-6	5	.719	*132,895	95,551	0	1.00	1.86	177,725
4	6-10	8	1.531	*78,563	120,280	0	1.60	2.46	295,889
5	10-15	12.5	1.237	52,886	65,420	0	2.50	3.36	219,811
6	15-20	17.5	1.054	49,936	52,633	0	3.50	4.36	229,480
7	20-25	22.5	.220	76,189	16,762	0	4.50	5.36	89,844
8	25-30	27.5	.205	73,803	15,130	0	5.50	6.36	96,227
9	30-40	35	.094	157,994	14,851	0	7.00	7.86	116,729
10	40-50	45	.074	261,490	19,350	.50	9.50	10.86	210,141
11	50-150	100	.00515	5,268,207	27,131	1.00	21.00	22.86	620,215
			Total Visits V =		580,290	Recreation Benefits B(S) =			$2,251,957

(1) Zone number. (2) Mileage range of zone margins. (3)One way distance from park to center of zone, in miles. (4) New Unit recreation demand in visits per capita, 1.51 times the original. (5) 1960 (*1967) population of each zone, by individuals. (6) Annual attendance from each zone in visits. (7) Estimated travel associated cost per visit from each zone in dollars. (8) Travel cost in dollars per visit to visitors from zone J, K=10 cents per mile. (9) Total cost per visit in dollars to visitors from zone J, R = $0.86. (10) Annual recreation benefits in dollars for each zone.

10. Unit Recreation Demand for Each Zone

The unit recreation demand in visits per capita for each zone is listed in column (10) of Table XII and is calculated as the ratio of annual visits from each zone, V(J), to the population of the zone P(J). Table XVIII shows the unit recreation demand for Green Lakes State Park.

11. Onondaga Lake Annual Recreation Benefits at Green Lake Water Quality

Table XIX shows the calculation of total annual recreation benefits of $2,251,957 for Onondaga Lake at Green Lake water quality.

Unit recreation demand from Green Lake is used to estimate the demand for Onondaga Lake at Green Lake water quality. Comparing the unit recreation demands of Onondaga Lake at existing quality, which are shown in column (10) of Table XII, with those of Green Lake, which are shown in column (6) of Table XVIII, it is noted that for four zones, the unit recreation demands V(3)/P(3), V(4)/P(4), V(5)/P(5), and V(6)/P(6), at Green Lake are less than those for Onondaga Lake. This underscores the fact that the unit recreation demand is not solely dependent upon water quality. The demand is affected by other factors such as the physical characteristics of the recreation area, characteristics of the surrounding population (Dutta and Asch, 1966), and the degree of over-crowding at the recreation area.

In order to compensate for characteristics of the population within a fifty mile radius of the park entrance, a unit recreation demand was calculated for a composite of zones 1 through 10 and is the ratio of the total visits from these zones to the total population of these zones. The compensated unit recreation demand for Onondaga Lake is 0.3522 visits per capita and for Green Lake is 0.3985 visits per capita.

It is assumed then that Onondaga Lake at Green Lake water quality will have a unit recreation demand for each zone that is 1.51 times greater than it is at existing quality. This is shown in column (4) of Table XIX, where each V(J)/P(J) is 1.51 times greater than the corresponding V(J)/P(J) in column (10) of Table XII. For example, V(3)/P(3) in Table XIX equals 0.719 which is 1.51 x 0.476 from Table XII.

In Table XIX, the new unit recreation demand for each zone V(J)/P(J), is multiplied by the population of each zone in column (5) to produce an estimate of annual attendance from each zone, V(J), in column (6). For example, for zone 3, the new V(3)/P(3) times P(3) is 0.719 x 132,895 or V(3) equals 95,551 visits. Total cost per visit for each zone C(J) is calculated as before, using the weighted average base cost per visit R, equal to $0.86, from Green Lake. This value is entered in column (9). Annual recreation benefits are then calculated for each zone as V(j) x C(J) and entered in column 10. For example, for zone 3, recreation benefits are V(3) x C(3) equals 95,551 x $1.86 equals $177,725. Total annual recreation benefits for Onondaga Lake at Green Lake water quality are obtained by summing column (10):

$$B(S) = \sum_{J=1}^{11} V(J) \times C(J) = \$2,251,957 \qquad (4)$$

12. Annual Additional Cost of Onondaga Lake Park Maintenance and Operation at Green Lake Water Quality

It is assumed that the annual additional cost of park maintenance and operation, G(2), at Onondaga Lake Park at Green Lake water quality will increase in direct proportion to the increased park attendance. The present attendance is 384,166 and the estimated new attendance is 580,290 (Table XIX, column 6). The new annual additional cost of park maintenance and operation is estimated to be:

$$\begin{aligned} G(2) &= 580,290/384,166 \times G(1) \\ &= 2.92 \times \$73,624 = \$214,982 \qquad (5) \end{aligned}$$

13. Onondaga Lake Annual Fishing Benefits at High Water Quality

This researcher believes that Onondaga Lake will support a significant amount of sport fishing use at a higher water quality than presently exists. The Bureau of Outdoor Recreation (1967:B-2) estimated that sport fishing demand in the Lake Ontario Basin in 1960 was 3.33 visits per person per year, as shown in Table XX. In applying this demand, it is assumed that the percent of total individual demand that will be satisfied at Onondaga Lake decreases with increased distance from the lake. Table XXI shows potential sport fishing benefits at Onondaga Lake with high water quality. The percent of total fishing demand for each zone which will be satisfied at Onondaga Lake is arbitrarily assumed in column (4). Applying this percentage to the total demand of 3.33 visits per person gives the estimated unit recreation demand in column (5). Annual attendance from each zone V(J), in column (7), is calculated as the estimated unit recreation demand in column (5) times the zone population P(J) in column (6). The weighted average base cost per visit, R is assumed to equal $4.00 (Kinney, 1964:27) and the total costs per visit for each zone C(J), are calculated as before from equation (2). Annual sport fishing benefits are then calculated for each zone as V(J) times C(J) and are entered in column (11). Total annual sport fishing benefits for Onondaga Lake at high water quality are obtained by summing column (11):

Table XX

Demand for Selected Water-Oriented Outdoor Recreational Activities, Lake Ontario Basin, 1960 (Day and Overnight or Weekend Sectors)

Activity	Adjusted annual Participation Rate (Visits per Person)
Water-dependent	
Swimming	8.13
Fishing	3.33
Boating	1.81
Water-skiing	.33
Canoeing	.13
Sailing	.17
Subtotal	13.90
Water-enhanced	
Camping	.56
Picnicking	3.85
Sightseeing	5.51
Nature Walks	2.85
Hunting	1.38
Hiking	.42
Subtotal	14.27

Source: Bureau of Outdoor Recreation, 1967:B-2

Table XXI

Potential Sport Fishing Benefits at Onondaga Lake at High Water Quality

(1) J	(2)	(3) D(J)	(4)	(5) $\frac{V(J)}{P(J)}$	(6) P(J)	(7) V(J)	(8) A(J)	(9) T(J)	(10) C(J)	(11) C(J)x C(J)
1	0-2	1	50	1.65	86,868	143,332	0	.20	4.20	601,994
2	2-4	3	40	1.33	98,662	131,220	0	.60	4.60	603,612
3	4-6	5	30	1.00	121,585	121,585	0	1.00	5.00	607,925
4	6-10	8	20	0.67	60,210	40,341	0	1.60	5.60	225,910
5	10-15	12.5	10	0.33	52,886	27,452	0	2.50	6.50	178,438
6	15-20	17.5	5	0.17	49,189	8,489	0	3.50	7.50	63,668
7	20-25	22.5	4	0.13	76,189	9,905	0	4.50	8.50	84,192
8	25-30	27.5	3	0.10	73,803	7,380	0	5.50	9.50	70,110
9	30-40	35	2	0.07	157,994	11,060	0	7.00	11.00	121,660
10	40-50	45	1	0.03	261,490	7,845	.50	9.50	13.50	105,908
11	50-150	100	.01	0.0003	5,268,207	2,580	1.00	21.00	25.00	64,500
				Total Visits V =		511,189	Fishing Benefits B(F) =			2,727,917

(1) Zone number. (2) Mileage range of zone margins. (3) One way distance from park to center of zone, in miles. (4) Assumed percentage of individual fishing demand that will be satisfied at Onondaga Lake. (5) Assumed unit recreation demand in visits per capita, column (4) **times 3.33 visits** per person per year. (6) 1960 (*1967) population of each zone, by individuals. (7) Estimated annual attendance from each zone in visits, column (5) times column (6). (8) Travel associated cost per visit from each zone in dollars. (9) Travel cost in dollars per visit to visitors from zone J, K = $0.10 per mile. (10) Total cost per visit in dollars to isitors from zone J, R = $4.00. (11) Annual fishing benefits in dollars for each zone.

$$B(F) = \sum_{J=1}^{11} V(J) \times C(J) = \$2,727,917 \qquad (6)$$

14. Total Annual Recreation Use Benefits for Onondaga Lake at High Water Quality

Total annual recreation use benefits for Onondaga Lake at high water quality are equal to the sum of the recreation benefits B(S), the additional costs of park maintenance and operation G(2), and the potential sport fishing benefits B(F), as follows:

$$\begin{aligned} [B(R)]\ (2) &= B(S) + G(2) + B(F) \\ &= \$2,251,957 + \$214,982 + \$2,727,917 \qquad (7) \\ &= \$5,194,856 \end{aligned}$$

15. Annual Net Recreation Use Benefits at Onondaga Lake with Increased Water Quality

The annual net recreation use benefits at Onondaga Lake which will result from increased water quality are estimated to be:

$$\begin{aligned} [B(R)]\ \text{net} &= [B(R)]\ (2) - [B(R)]\ (1) \\ &= \$5,194,856 - \$1,479,416 \qquad (8) \\ &= \$3,715,440 \end{aligned}$$

Measurement of Withdrawal Water Use Benefits

1. Municipal Water Supply

Onondaga Lake is not presently used as a source for municipal water supply. It is a brickish water lake with high concentrations of calcium, sodium, bicarbonate, and chloride ions. These inorganic salts have originated from natural salt springs and from domestic and industrial pollution. Table XXII shows the chemical characteristics of Onondaga Lake and comparative values for Skaneateles Lake and Lake Ontario, both of which are presently being used for public water supply. It should be noted that the chloride concentration in 1965 was 1841 mg/l. The U.S. Public Health Service (1963:34) recommends "that waters containing more than 250 mg/l of chlorides or sulfates and 500 mg/l of dissolved solids not be used for drinking if other less mineralized supplies are available." The Onondaga Lake Scientific Council (1966:24) suggests that "it would appear that the inorganic salts in Onondaga Lake would not reduce the multiple use of the lake except for drinking water."

Table XXII

Chemical Characteristics of Representative New York Lakes

Chemical Characteristics	Location				
	Limestone Belt			North Appalachian Plateau	Lake Plain
	Onondaga Lake		Fayetteville Green Lake 1955 (2)	Skaneateles Lake 1955 (2)	Lake Ontario Nine-Mile Point Oswego 1955 (2)
	1955 (2)	1965 (1)			
pH	7.7	-	7.5	7.5	7.9
Conductivity (Micromhos)	5010	-	1960	231	306
ppm					
Alkalinity	106.6	-	157.4	93.4	92.6
Ca	472	555	400	36	38
Mg	13	18.7	62	6.2	8.0
Na + K	538	1048	14.6	2.9	10.4
Fe	0.28	-	0.02	0.18	0.05
HCO_3	130	152	192	114	113
SO_4	167	198	1050	16	25
Cl	1460	1841	24	3.6	23
NO_3	11.0	-	4.7	2.0	0.7

Source: (1) Onondaga Lake Scientific Council, 1966:21.

(2) Berg, 1963: 201.

The City of Syracuse presently withdraws a maximum of 54 mgd (204,390 cubic meters per day) of water from Skaneateles Lake. Considering a probable reduction in future demand caused by high salinity, it is assumed that 25 mgd (94,625 cubic meters per day) of water will be demanded for municipal water supply, if the quality of Onondaga Lake were similar to that of Skaneateles Lake, neglecting the concentrations of inorganic salts.

The benefits of municipal withdrawal water use at this quality are estimated to be equal to 12 cents per 1000 gallons or $120 per million gallons, the current cost of water treatment by coagulation, sedimentation and rapid sand filtration (Koenig, 1967). The annual municipal withdrawal water use benefits for Onondaga Lake will be:

$$\begin{aligned} [B(M)]\ (1) &= \$120/\text{mg} \times 25\ \text{mg/day} \times 365\ \text{days/year} \\ [B(M)]\ (2) &= \$1{,}095{,}000/\text{year} \end{aligned} \qquad (9)$$

There is no existing municipal withdrawal of water and the existing municipal annual withdrawal use benefits are therefore zero:

$$[B(M)]\ (1) = 0 \qquad (10)$$

The net annual benefits thus equal those at Skaneateles water quality:

$$\begin{aligned} [N(M)]\ (\text{net}) &= [B(M)]\ (2) - [B(M)]\ (1) \\ [B(M)]\ (\text{net}) &= \$1{,}095{,}000 - 0 \\ [B(M)]\ (\text{net}) &= \$1{,}095{,}000 \end{aligned} \qquad (11)$$

2. Industrial Water Supply

The industrial Chemicals Division of the Allied Chemical Corporation annual uses 100 mgd (378,000 cubic meters per day) of cooling water which is withdrawn from Onondaga Lake. This water is chlorinated at a cost of $300,000 per year, to prevent slime growth and resultant loss of heat transfer capacity in the heat exchanger equipment (Bliven, 1967). This is the main industrial use for Onondaga Lake water at existing quality and the industrial annual water use benefits are negative and may be taken to be equal to:

$$[B(Q)]\ (1) = \$300{,}000 \qquad (12)$$

Chlorination may not be required at improved water quality since the water will be cleaner and slime growth should be decreased. At this water quality the cost of chlorine and therefore the damages will be zero. The industrial annual water use benefits at high quality are therefore zero:

$$[B(Q)]\ (2) = 0 \qquad (13)$$

and the net industrial annual water use benefits are:

$$\begin{aligned}&[B(Q)]\ (\text{net}) = [B(Q)]\ (2) - [B(Q)]\ (1)\\&[B(Q)]\ (\text{net}) = 0 - (-\$300{,}000) = \$300{,}00\end{aligned}\tag{14}$$

3. Agricultural and Farmstead Water Supply

Onondaga Lake is not presently a source of agricultural or farmstead water and this use is not anticipated at an increased water quality. Agricultural and farmstead water annual use benefits at existing water quality, and at high water quality are zero and thus net benefits are also zero:

$$[B(A)]\ (1) = [B(A)]\ (2) = [B(A)]\ (\text{net}) = 0 \tag{15}$$

4. Total Annual Withdrawal Water Use Benefits

The total annual withdrawal water use benefits for Onondaga Lake at existing water quality are estimated to be:

$$\begin{aligned}&[B(WI)]\ (1)\ [B(M)]\ (1) = [B(Q)] + [B(A)]\ (1)\\&[B(WI)]\ (1) = 0 - \$300{,}000 + 0 = \$300{,}000\end{aligned}\tag{16}$$

Total annual withdrawal water use benefits at drinking water quality may be estimated to be:

$$\begin{aligned}&[B(WI)]\ (2) = [B(M)]\ (2) + [B(Q)]\ (2) + [B(A)]\ (2)\\&[B(WI)]\ (2) = \$1{,}095{,}000\end{aligned}\tag{17}$$

5. Net Annual Withdrawal Water Use Benefits

Net annual withdrawal water use benefits are:

$$\begin{aligned}&[B(WI)]\ (\text{net}) = [B(WI)]\ (2) - [B(WI)]\ (1)\\&[B(WI)]\ (\text{net}) = \$1{,}095{,}000 - (-\$300{,}000)\\&[B(WI)]\ (\text{net}) = \$1{,}395{,}000\end{aligned}\tag{18}$$

Measurement of Wastewater Disposal Benefits

A plan to improve treatment of the wastes entering Onondaga Lake has been approved by the New York State Department of Health. The plan basically involves an increase in the capacity of and the addition of activated sludge biological treatment and lime precipitation tertiary treatment to the existing Metropolitan Waste Treatment Plant. Wastes from Ley Creek sewer district; the Lakeland sewer district, located on the southwest shore of Onondaga Lake and including the New York

State Fairgrounds and the Allied Chemical Corporation will be combined with the existing waste flows of the City of Syracuse and treated jointly. It is claimed that the tertiary lime precipitation process which follows the secondary treatment will remove 50 percent of the toxic metals (coppyer, chromium and iron), 92 percent of the phosphate nutrients, 88 percent of the organic sewage material and 80 percent of the oil and grease. The Curcible Steel Corporation wastes will be treated separately (Hennigan, 1968b). This proposed waste treatment is planned to satisfy the minimum effluent standards of the New York State Department of Health.

The estimated construction costs for these projects are \$28.8 million as shown in Table XXIII. An equivalent annual cost may be calculated by using the capital recovery factor and assuming the \$28.8 million is amortized over 20 years at 4 percent interest. The capital recovery factor may be computed as: i(1 + i) N/ [(1+i)N-11] where i represents the interest rate per annum(expressed as a decimal) and N represents the years of estimated life (Linsley and Franzini, 1964. The capital recovery factor is 0.07358 and when multiplied by the total capital cost of \$28.8 million, it gives an annual cost of \$2,119,104.

Annual operating costs for the plant are estimated to be \$465,000 per year (Hennigan, 1968b).

Total annual wastewater disposal benefits at existing water quality are estimated to be at least equal to the total annual costs of waste treatment which will satisfy minimum standards:

$$[B(WD)]\ (1) = \$2{,}119{,}104 + \$465{,}000$$

$$[B(WD)]\ (1) = \$2{,}584{,}104 \tag{19}$$

Total annual wastewater disposal benefits at a higher water quality which will occur when pollution standards are being met are assumed to be zero:

$$[B(WD)]\ (2) = 0 \tag{20}$$

Net annual wastewater disposal benefits at higher water quality are negative and may be considered as damages to the present waste dischargers:

$$\begin{gathered}[B(WD)]\ (\text{net}) = [B(WD)]\ (2) - [B(WD)]\ (1) \\ [B(WD)]\ (\text{net}) = 0 - \$2{,}584{,}104 = \$2{,}584{,}104\end{gathered} \tag{21}$$

Measurement of Bordering Land Use Benefits

1. Bordering Land Use Benefits at Existing Water Quality

Table XXIII

Estimated Construction Costs for Onondaga Lake Waste Treatment Facilities

Facility	Construction Cost in millions of dollars
Pumping Ley Creek Wastes to the Metropolitan Plant	3.5
Pumping Lakeland Wastes to the Metropolitan Plant	1.7
Secondary Waste Treatment at the Metropolitan Plant	15.0
Tertiary Waste Treatment at the Metropolitan Plant	8.6
Total Construction Costs	28.8

Source: Hennigan, 1968b.

Table XXIV

Onondaga Lake Bordering Property Value Benefits at Existing Water Quality

Character of property	Total Assessed Value of Shoreline Property A	Total Assessed Value of Sample non-shoreline Property B	Equalization Rate Decimal Fraction C	Total Full Value of Shoreline Property D=A/C	Total Full Value of Sample Non-Shoreline Property E=B/C	Number of acres of Shoreline Property F	Number of Acres of Sample Non-Shoreline Property G	Value Per Acre of Shoreline Property H=D/F	Value Per Acre of Sample Non-Shoreline Property I=E/G	Ratio of Shoreline Value Per Acre to Non-Shore-Value Per Acre J=H/I	Bordering Property Benefits (+) or Damages (-) K=F×I(J-1)
Seg.1(1)	$750,000		.24	$3,125,000		340		$9,191			
Seg.1(2)		$120,400	.24		$501,667		40.71		$12,323	0.746	-1,064,880
Seg.2(3)						175		$515			
Seg.2(4)		$ 47,450	.22		$215,682		259.51		$ 831	0.620	-55,300
Seg.3(5)	$7,900		.22	$35,908		205.55		$175			
Seg.3(6)		$112,000	.22		$509,091		192.83		$2,640	0.066	-506,680
Seg.4(7)	$110,575		.40	$276,438		211.36		$1,308			
Seg.4(8)		$351,800	.40		$879,500		114.32		$7,693	0.170	-1,349,597

(1) Onondaga Lake Park. (2) Town of Salina and Village of Liverpool. (3) West Shore Park. (4) Town of Geddes. (5) Industrial Shoreline in Town of Geddes. (6) Non-shoreline industrial to town of Geddes. (7) Industrial and commercial shoreline, Syracuse. (8) Industrial and commercial non-shoreline, Syracuse.

Total Benefits = $2,976,457

The effect of water quality on the value of property bordering Onondaga lake is estimated at existing water quality by comparing the per acre market value of non-shoreline property. Assessed property values and the other information shown in Table IX were obtained from the 1967 Onondaga County Tax records (O'Connor, 1968) and the 1967 City of Syracuse Tax records (Ginggold, 1968).

The four segments of land use classification for the property bordering Onondaga Lake as shown in Figure 3, are used in the estimation of land use benefits. Table XXIV shows the calculation of benefits or damages for each of these segments. Segment #1 contains Onondaga Lake Park with an area of 340 acres. The Park per acre market value is calculated from the assessed value and is compared with the per acre unimproved or land value of 195 parcels of non-shoreline property in the Town of Salina. These non-shoreline properties have a total area of 40.71 acres and most of them are lots for one family residences. Segment #1 has a ratio of shoreline value per acre to nonshoreline value per acre of 0.746 and bordering property damages in column (K), are estimated to be $1,064,880, which are calculated as 340 acres of shoreline property listed in column (F), times $9,191, the value per acre of non-shoreline property in column (I), times the quantity 0.746, the ratio of shoreline value per acre to non-shoreline value per acre in column (J) minus 1. It is noted that these damages may also be calculated by multiplying the 340 acres of shoreline property in column (F) times the quantity $9,191, the value per acre of shoreline property in column (H) minus $12,323, the value per acre of sample non-shoreline property in column (I). The second calculation may seem simpler but the first calculation may be used in estimating the benefits at existing quality and also at an improved quality where the ratio of shoreline value per acre to non-shoreline value per acre is expected to change.

Segment #2 contains the West Shore Park with an area of 175 acres. The property has no assessed valuation listed in the tax records since it was received by Onondaga County as a free gift from New York State (Shattuck, 1968b). The market value per acre of this shoreline property is estimated by the following method. In 1964 Onondaga County acquired 34 acres of swampland along Long Branch Road near the West Shore Park area. The average cost was $477 per acre (Shattuck, 1965:11). Assuming that the value of this property has appreciated approximately 2 percent annually, the 1968 value will be $515 per acre which is taken as the park property value. The per acre unimproved or land value of 141 parcels of non-shoreline property is determined from the assessed values. These non-shoreline properties have a total area of 259.51 acres and most of them are lots for one family residences. Segment #2 has a ratio of shoreline value per acre to non-shoreline value per acre of 0.620 and the bordering property value damages are estimated to be $55,300.

Segment #3 has 3 parcels containing 205.55 acres of industrial property bordering Onondaga Lake which are owned by the Allied Chemical Corporation. Most of this property is used for the disposal of Allied Chemical Corporation process wastes in large beds. The per acre market value of this property is calculated from the assessed value and compared with the per acre unimproved or land value of 11 parcels of non-shoreline industrial property also owned by the Allied Chemical Corporation. This property has an area of 192.83 acres and is located in the Town of Geddes. Segment #3 has a ratio of shoreline per acre value to non-shoreline per acre value of 0.066 and bordering property damages are estimated to be $506,680.

Segment #4 has 16 parcels containing 211.36 acres of commercial and industrial property in the City of Syracuse and bordering Onondaga Lake. The per acre market value of this property, as calculated from the assessed value is compared with the per acre unimproved or land value of 11 parcels of non-shoreline commercial and industrial property. This property has an area of 114.32 acres. Segment #4 has a ratio of shoreline per acre value to non-shoreline per acre value of 0.170 and bordering property damages are estimated to be $1,349,597.

Total bordering land use benefits at existing water quality are determined by taking the algebraic sum of column (K) in Table XXIV. The result is negative and thus indicates a damage value:

$$[B(LT)]\ (1) = \$2,976,457 \qquad (22)$$

Total annual bordering land use damages at existing water quality may be estimated by assuming the total damages are prorated over a five year period, a length of time which measurable change in water quality should occur following the installation of improved wastewater treatment, or the length of time necessary for a degraded water quality to have its full effect on land values:

$$\begin{aligned}[B(L)]\ (1) &= [B(LT)]\ (1)/5 = -\$2,976,457/5 \\ [B(L)]\ (1) &= \$595,291\end{aligned} \qquad (23)$$

2. Bordering Land Use Benefits at Skaneateles Lake Water Quality

The ratio of the per acre land or unimproved market value of shoreline property on Skaneateles Lake to non-shoreline property located in the Town of Skaneateles is computed in Table XXV and is equal to 1.974. There is 66,000 feet of lake frontage in the Town of Skaneateles and 418 parcels of property bordering the lake, totaling 783.56 acres in area with land use divided 46 percent as seasonal residences and 26 percent one family residences occupied year around.

The assessed value and area of 23 parcels of non-shoreline property chosen for comparison are multiplied by a weighting factor which duplicates the percentage distribution, by use of the shoreline property. For example, the assessed values and area of the parcels in the non-shoreline sample which are seasonal residences are weighted such that they represent 46 percent of the total sample, the percent

Table XXV

Skaneateles Lake Ratio of Shoreline Property Values to Non-shoreline Property Values

Character of property	Total Assessed Value of Shoreline Property	Total Assessed Value of Sample Non-shoreline Property	Equalization Rate Decimal Fraction	Total Full Value of Shoreline Property	Total Full Value of Sample Non-Shoreline Property	Number of Acres of Shoreline Property	Number of Acres of Sample Non-Shoreline Property	Value Per Acre of Shoreline Property	Value Per Acre of Sample Non-Shoreline Property	Ratio of Shoreline Value Per Acre to Non-Shoreline Value Per Acre
	A	B	C	D=A/C	E=B/C	F	G	H=D/F	I=E/G	J=H/I
Shoreline	$864,200		.28	$3,086,429		783.56		$3,939		
Non-shore line		$293,392	.28		$1,047,829		525.26		$1,995	1.974

Table XXVI

Onondaga Lake Bordering Property Value Benefits at Skaneateles Lake Water Quality

Character of Property Segment	Number of Acres of Shoreline Property F	Value Per Acre of Sample Non-shoreline Property I	Ratio of Shoreline Value Per Acre to Non-shoreline Value per acre J	Bordering Property Benefits (+) or Damages (-) K = FxI(J-1)
#1	340	$12,323	1.974	$4,080,885
#2	175	$831	1.974	$141,644
#3	205.55	$2,640	1.974	$528,517
#4	211.36	$7,693	1.974	$1,583,716
			Total Benefits =	$6,334,762

that seasonal residence land use is to total shoreline land use. The resulting weighted assessed value and area are entered in columns (B) and (G) respectively of Table XXV.

Total bordering land use benefits for Onondaga Lake at Skaneateles Lake water quality may be estimated by assuming that the ratio of per acre shoreline property value to per acre non-shoreline property value may be projected from Skaneateles Lake to Onondaga Lake. Assuming at Onondaga Lake the non-shoreline property values remain unchanged, the bordering property value benefits for each segment are calculated in column (K) of Table XXVI.

Total bordering land use benefits at Skaneateles Lake water quality are determined by taking the algebraic sum of column (K) in Table XXVI:

$$[B(LT)]\ (2) = \$6{,}334{,}762 \qquad (24)$$

Total annual bordering land use benefits at Skaneateles Lake water quality may be estimated by assuming the total benefits are prorated over a five year period:

$$[B(L)]\ (2) = [B(LT)]\ (2)/5 = \$6{,}334{,}762/5 \qquad (25)$$

$$[B(L)]\ (2) = \$1{,}266{,}952$$

3. Net Annual Bordering Land Use Benefits

Net annual bordering land use benefits for Onondaga Lkae at Skaneateles Lake water quality may be calculated as:

$$[B(L)](net) = [B(L)]\ (2) - [B(L)]\ (1)$$

$$[B(L)]\ (net) = \$1{,}266{,}952 - (-\$595{,}291) \qquad (26)$$

$$[B(L)]\ (net) = \$1{,}862{,}243$$

Measurement of In-Stream Water Use Benefits

The immediately measureable effects of water quality on in-stream water uses of Onondaga Lake are limited to navigation damages caused by the deposition of organic sludge and silt at the mouth of Onondaga Creek. This material fills the turning basin at the New York State Barge Canal Terminal and must be removed each year. Table XXVII shows the average annual quantity of material removed from the area by a fifteen inch hydraulic dredge owned by the State.

The cost of dredging is estimated to be $1.00 per cubic yeard (0.7646 cubic meters) (ENR, 1968a:43; ENR, 1968:45; Timbello, 1968) and navigation damages are estimated to be:

Table XXVII

Quantities of Material Dredged from the Turning Basin at the Syracuse Barge Canal Terminal, Solar Street, Syracuse, New York

Year		Quantity Removed cubic yards
1967		84,856
1966		298,173
1964		20,400
1963		80,470
1962		55,535
1961		27,083
	Total	566,517
Average for the 7 year period		80,931

Source: Milovicz, 1968

$$\begin{aligned} &ND(1) = 80{,}931 \text{ cubic yards} \times \$1.00/\text{cubic yard} \\ &ND\ (1) = \$80{,}931 \end{aligned} \qquad (27)$$

Annual in-stream water use benefits at existing water quality are estimated to be:

$$\begin{aligned} &[B(IS)]\ (1) = ND\ (1) \\ &[B(IS)] = (1) = \$80{,}931 \end{aligned} \qquad (28)$$

Annual in-stream water use benefits at a higher water quality with prevention of sludge deposition in the turning basin are estimated to be zero:

$$[B(IS)]\ (2) = 0 \qquad (29)$$

Net annual in-stream water use benefits at high water quality are estimated to be:

$$\begin{aligned} &[B(IS)](\text{net}) = [B(IS)]\ (2) - [B(IS)]\ (1) \\ &[B(IS)]\ (\text{net}) = 0\ (-\$80{,}931) = \$80{,}931 \end{aligned} \qquad (30)$$

Total Annual Social Benefit for Onondaga Lake

1. Total Annual Social Benefit for Onondaga Lake at Existing Water Quality

The total annual social benefit for Onondaga Lake at existing water quality may be estimated by summing the results obtained in the five surveys:

$$\begin{aligned} B(1) &= [B(R)]\ (1) + [B(WI)]\ (1) = [B(WD)]\ (1) \\ &\qquad + [B(L)]\ (1) + [B(IS)]\ (1) \\ B(1) &= \$1{,}479{,}416 - \$300{,}000 + \$2{,}584{,}104 \\ &\qquad - \$595{,}291 - \$80{,}931 \\ B(1) &= \$3{,}087{,}298 \end{aligned} \qquad (31)$$

2. Total Annual Social Benefit for Onondaga Lake at an Improved Water Quality

The total annual social benefit for Onondaga Lake at an improved water quality comparable to Green Lake and Skaneateles Lake may be estibated by summing as follows:

$$\begin{aligned} B(2) &= [B(R)]\ (2) + [B(WI)]\ (2) + [B(WD)]\ (2) \\ &\qquad + [B(L)]\ (2) + [B(IS)]\ (2) \\ B(2) &= \$5{,}194{,}856 + \$1{,}095{,}000 + 0 + \$1{,}266{,}952 + 0 \\ B(2) &= \$7{,}556{,}808 \end{aligned} \qquad (32)$$

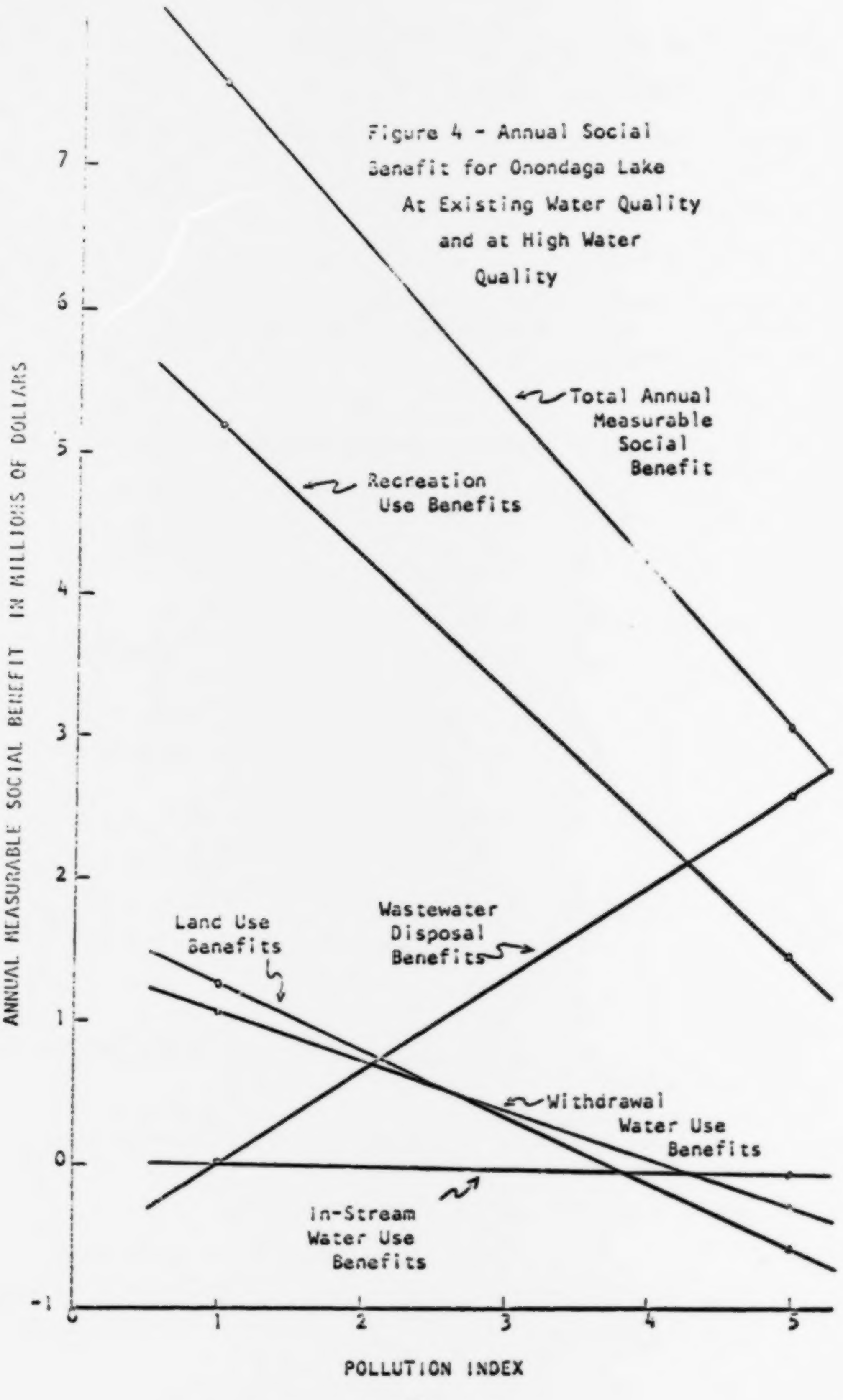

Figure 4 - Annual Social Benefit for Onondaga Lake At Existing Water Quality and at High Water Quality

3. Net Annual Measurable Social Benefit for Onondaga Lake at High Water Quality

The net annual measurable social benefit for Onondaga Lake at high water quality is the dollar value to water users in changing from existing water quality to the high water quality. It is calculated as follows:

$$B\ (\text{net}) = B(2) - B(1) = \$7{,}556{,}808 - \$3{,}087{,}298$$

$$B\ (\text{net}) = \$4{,}469{,}510 \qquad (33)$$

The net annual measurable social benefit is shown in Figure 4 plotted against pollution index. A pollution index of 5.4 has been calculated for Onondaga Lake using water quality data gathered in 1960 (Sumitomo, 1968). Therefore, a pollution index of five (5) has been assumed to indicate its existing water quality. A pollution index of one (1) is assumed to represent Onondaga Lake at an unpolluted quality.

SECTION XI

ACKNOWLEDGEMENT

Many persons have contributed in one way or another to the research reported in Part B. We would like to personally thank them all and will note that many persons with varied backgrounds very willingly shared with us their knowledge and opinions on water pollution control. We wish to especially acknowledge several people who have made particular contributions.

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SECTION XII

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PART C - BENEFITS OF WATER QUALITY ENHANCEMENT

DEVELOPED BY

NELSON L. NEMEROW AND JOHN KARANIK

SECTION I

CONCLUSIONS

The objective of this part of the project has been basically threefold:

a) to advocate the administration of water pollution abatement at the regional rather than State or Federal level;
b) to present a methodology for selling the pollution carrying capacity of water based on benefits foregone due to pollution; and
c) to report on an attempt to achieve a trial status for a regional board selling assimulative capacity.

The arguments for regional control have admittedly been underplayed, not due to the lack of potential merit, but to the lack of sufficient experiences and evaluations. The water pollution problem has been in existence for some time, but not until recently has its severity been fully appreciated. Until the full impact of the problem became known to the man-on-the-street, if indeed this event has taken place, pollution control efforts were of a piecemeal, local nature. Before individual communities became aware that their neighbors were having the same problems and attempting the same solutions as themselves, the State and Federal governments had rapidly moved in and established themselves as the "powers that be". Both have strengthened their positions to the point where communities are now almost completely dependent upon them for legislation, regulation, planning, development and financing. A consequence of this evolution is that local problems and desires are often overlooked in favor of the larger scope efforts.

The debate concerning regional versus State or Federal Control will no doubt continue for many years due to the various types of programs applicable to both. This research has not conclusively established that one is more preferable than the other. It was not the intention to do so, and in fact could not be done within the context of the overall investigation without first obtaining enabling legislation. It was, however, a matter of interest to determine the potential for regional controls and the experiences of those in existence. Toward this end, two satellite projects were suggested by the author and carried out my May (28) and Keenan (31). Keenan, in summarizing his investigations, concludes that "The river basin authority approach is the most efficient administrative mechanism for the management of water resources." He discusses two basically similar schemes, both of which entail the river basin as the local unit;

"The first alternative might be seen as a small scale Delaware River Basin Commission. That is, the agency would be responsible for the basin-wide planning for the development and protection of

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its water resources. In addition, the commission would have the authority to implement the provisions of its plan. The commission would operate as a special taxing district. There are two ways in which local representation could be achieved. The members would represent each town, village or city in the basin, or in the case of a larger basin, each county. The commissioners should be elected directly by the people or by the governmental sub-unit involved. Representation in this case should be proportionate to local population. In addition, there should be state representatives to be appointed by either the Governor or by the State Health or Water Resources Commissioner. These state representatives are needed to offer technical competence and to present the views of the State government. The other method for basing representation on the basin board is to have membership based upon water consumption rather than population. This technique would probably represent the industries of the region in a more equitable manner. However, since decisions are to be made on a best use basis, it seems reasonable therefore to base representation upon water use.

The second alternative allows for the establishment of policy at the state level, and implementation at the local level. There are several advantages associated with this administrative method. First policy is set by the largest governmental unit in the state. Hence the water resources policy will be determined within the context of the over-all developmental goals of the state. It is possible that the "big picture" could be lost by a wholly autonomous local special district. Second, the idea of a local river basin agency will be retained. These regional agencies would be responsible for meeting the State's policy guidelines by the activation of local projects. The local body would be permitted to decide upon the most economical and efficient means in order to fulfill the expectations of the State policy. The actual provisions agreed upon by the local agency would be based upon considerations involving the river basin as a unit. Third, this system would be more acceptable to State officials as it would entail the retention of more state authority than the previously discussed alternative.

It would, of course, be necessary to provide sufficient power to the local agencies. In this respect, the agency would require the power to collect property taxes, user fees, effluent charges, or some combination of the three in order to finance planning studies and to implement the resultant schemes for the basin-wide management of water. The agency should have the capability of enforcing its decisions. Representation on the local boards should be essentially the same as that discussed above.

The river basin authority approach is the most efficient administrative mechanism for the management of water resources. The most practical means of establishing such a program involves a state planning agency to set policy, and a local basin agency to implement the policy decisions. The river basin authority should be capable of meeting these goals within the context of the basin as a whole. Consequently, basin-wide representation on the board should be in proportion to either population or water use."

Keenan's conclusions basically support the contention of the authors. The operational success of existing river basin authorities leads one to believe that the regional approach is indeed the preferred alternative. The manner in which board membership is determined, however, is a matter that is unresolved. More will be said concerning this later in this chapter.

Keenan makes reference to the financing of regional basin boards. The proposed methodology affords a means by which such boards could secure operating funds, as well as funds for other purposes, and instill incentive for waste treatment.

In view of the lack of criticism from the Eastern Oswego Board (EOB), or from any other source, it can only be concluded that the sale of assimilative capacity is a suitable means for achieving pollution abatement through a cooperative rather than regulatory or legislative approach. The concept of selling assimilative capacity, based on increasing bost with decreasing resource, and the method of calculating unit prices, is not a "cure-all", is not a precise determination, and likely possesses several reasons for discounting its validity. It does, however, provide a starting point for relating foregone benefits, water quality and available resources. Although it may not be an explicit relationship, it is a rational approach toward establishing the regional value of pollution abatement, and provides revenue for operation and development.

It is felt that the proposal is better suited for regional boards than for higher authorities. This, of course, is unsubstantiated. It is however, considered to be a reasonable conslusion for the following reasons:

1) The beneficiaries are easier to define;
2) Regional knowledge of regional problems and desires surpasses that of higher authorities;
3) The disparity of activity, costs and benefits from one region to another would make it very difficult and time-consuming for a higher authority to apply the principles suggested;
4) Application of the proposal by higher authorities would tend to favor political rather than hydrological boundaries, especially in basins crossing state lines; and
5) Regional applications would present only minor bookkeeping problems since all expenditures and revenues would be internal (much like a completely new political entity), whereas application by higher authorities would result in massive bookkeeping problems, require increased numbers of personnel and allow for the continuance of external diseconomies.

It had originally been intended to report on the operation of a regional board utilizing the resource sales concept. Considerable time was spent, however, on developing the method, explaining it to the EOB, and demonstrating the manner in which an enforcement agency could utilize it. Sufficient time remained to test the theory, but when negotiations with the board were discontinued there was no possibility of attempting another approach in time to meet the deadline established by the research contract. There is much to be concluded, however, regarding the operation of local river basin planning boards and the feasibility of such boards utilizing the proposed methodology.

The current structure of such boards precludes their making use of the proposal for other than academic purposes. They have no authority, can take no action, have an extremely limited budget, are virtually entirely dependent upon the State for technical assistance and, due in part to their vague existence, receive little or no local support. If the specific criticisms listed below are corrected, the authors are confident that similar regional boards could provide competent and efficient pollution control programs:

1) The enabling legislation creating the local boards is quite restrictive and maintains planning controls at the State level. The legislation is for all intents and purposes a feeble attempt to allow for regional participation in water resources in planning and development.
2) Water Quality control is not one of the responsibilities of such boards in planning endeavors. It makes little sense to separate all other water uses from pollution abatement, especially when one considers the considerable amount of interaction between all uses.
3) The selection of board members is made by the State from a list of names supplied by the participating counties. The reasons for this are unclear and cast additional doubt on the role to be played by the regional boards.
4) The specific interest group representation appears to be adequate but tha qualification requirements of representatives leaves something to be desired. The integrity and intentions of the representatives cannot be questioned but reasons for the selection of some specific members can be. For example, on the EOB, the industrial representative is the editor of the area. It can be safely assumed that he is familiar with industrial pulse within his community but the same cannot be said of this familiarity with other areas of the basin. There are other similar examples that could be cited. The point is, interest groups representation should be interest group representation and not the casual filling of seats that the present system appears to be at times.
5) Involvement with staff activities is not sufficient to create maximum interest and education of members. This could be improved by compensating members, having true interest group

representation and/or hold meetings at a greater frequency.

6. The present structure allows members to participate on the board until such time as the "plan" is complete. If a particular interest group is of the opinion that they are not receiving adequate representation, there is no recourse.
7. Upon completion of planning efforts, the board expires. There is no provision for plan development and implementation and in fact no assurance that the plan will be accepted by the State.

SECTION II

RECOMMENDATIONS

The structure of local planning boards is perhaps adequate within the context of the boards responsibilities. However, if regional participation and "Home rule" are the policies guiding State activities it would appear certain that several legislative changes are required. Given these changes, regional boards could surely utilize the proposed methodology. It is interesting to read a recent publication by the State (32):

"An essential component of the complex process of managing water resources is the formulation of rational water policies. These should be designed to reflect the public interest, facilitate realization of objectives, and promote equitable distribution of costs and benefits in the pursuit of such objectives. Water laws and the policies associated with their implementation require frequent re-examination to ascertain their adequacy in the light of changing conditions and social goals. While the State has been progressive in this respect, notably through initiation of analysis of riparian rights and in the promulgation of water quality standards, the reconnaissance reports highlight situations where legal and policy adjustments would broaded alternative choices for achieving efficient use of water resources. This particularly is true with respect to cost-sharing policies."

"Reliance for maintaining water quality in New York State currently is centered on two techniques - high degree treatment at the source of waste discharges and low-flow augmentation, with low-flow augmentation considered as a possible supplement to treatment. Management of quality invites consideration of a range of technologic alternatives along with institutional arrangements to facilitate their financing, construction and an operation. Policies should be explored that will encourage application of these alternatives".

In light of the above statements, as well as other findings of the study, the following specific recommendations are made:

1) The concept of resource sales by a regional regulatory board remains untested. Legislative and/or administrative actions should be encouraged to promote a trial board for some specified period of time. This could be attempted by contact with another board similar to the EOB, with state legislators or state pollution control authorities. Despite the results of talks with the EOB, it is still felt that the first alternative holds the most promise.

2) Concurrent with attempting to create a trial board, legis-

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lation should be drafted that would account for the criticisms of the present structure of local boards. The experiences of the trial board would certainly require alterations to such legislation, but in the meantime lengthy debates and arguments concerning the controversial approach may be settled.

3) Further investigations need to be carried out concerning the calculation of regional benefits and unit prices, as well as the relationships hypothesized on Figure 1.

4) Economic studies need to be conducted to determine the impact of regional boards on tax revenues to the State and Federal governments, as well as on the existing engineering staffs of both authorities.

5) The calculation of Pollution Index, while being a forward step, needs to be refined to account for not only physical and chemical parameters, but also the response of aquatic life to a particular type of effluents. This might be considered a type of Biological Index.

SECTION III

INTRODUCTION

Since the passage of the Federal Water Pollution Control Act of 1956, (1), the United States has experienced a deluge of water pollution control legislation and subsequent regulations. These have come about predominantly at the Federal and State levels. During this same time period, however, there has been little evidence to suggest that increased legislation has resulted in decreased degradation of water resources. Water quality problems continue to grow at an increasing and alarming rate, despite the expenditures of large amounts of tax dollars. There are many examples that could be cited but one will suffice to illustrate the point. "On a stretch of an unidentified interstate river, where $7.7 million had been spent on municipal sewage disposal plants since 1957, these facilities had reduced total pollution of the river by three per cent while the amount of industrial waste dumped into the same river in the same years had increased by 350 percent" (2). To say that recent legislation has done little to discourage water pollution would be closer to the truth.

Our current water pollution problems are reflections of an expanding economy and population, increased labor and construction costs, inadequate private awareness and representation, insufficient acceptance and use of basic economic principles, and inadequate assessments of benefits to be derived by water pollution abatement. As Fox (3) points out, "our water problems may be thought of as occuring in three major areas. One problem area is the urgent need of maintaining a continuously advancing science and technology, especially in water quality management. A very difficult and complex problem area is that of balancing costs and returns from water development and use. It has proven to be uncommonly difficult to achieve a consensus of costs and returns, which, in turn, has often made it difficult to proceed with water programs. A third problem area stems from the inadequacy of water management institutions. Laws, policies, and organizational arrangements have not kept abreast of the requirements of a rising demand and an advanced technology."

Part C of this project addresses itself to the latter two areas. A new type of administrative body will be proposed which will utilize economic principles and sell waste discharge "privileges". In developing a case for such a management scheme, the authors first considered current pollution control methods, and their shortcomings, and then attempted to relate economics to water pollution abatement administration. A case study is discussed in which the proposed system of pollution abatement was presented to a regional river basin planning board.

It is proposed that a local river basin board be established having the authority to govern and sell the water resources from within the basin. A modus operandi is presented in the following section using Onondaga Lake, Syracuse, New York, as an example.

SECTION IV

ADMINISTERING THE SALE OF ASSIMILATIVE CAPACITY

The Calculation of Unit Prices

It is recognized that every body of water has an assimilative capacity for any type of waste discharge. Although it is felt that the methodology to be discussed could be applied to any particular non-conservative contaminant of a waste, the author has confined his comments to the problem of oxygen consuming contaminants (primarily biodegradable organic matter). This has been done to make the demonstration as easily understood as possible, because dissolved oxygen is traditionally the major indicator of pollution and because one of the significant problems with Onondaga Lake is essentially that of low dissolved oxygen levels.

The proposal is that a regional board be empowered to sell the assimilative capacity of Onondaga Lake to those dischargers into the lake. Before doing so, the board would require at least the following information:

1) identity of all dscharges;
2) quantities of discharge;
3) existing and desired pollution index (a measure of water quality);
4) benefits of waste treatment; and
5) assimilative capacity.

The identities of, and loadings from dischargers to Onondaga Lake are presented in Table I:

TABLE I

Onondaga Lake Discharges

Discharger	Average Flow mgd	Pounds of Organic Load per day
A	129	43,500
B	40	74,000
C	75	300
D	2	100
E	14	100
F	5	5,000
Total	265 mgd	123,000 lb/day

Using the method developed by Sumitomo (20) it has been determined that the present pollution index (PI) of Onondaga Lake is 5.4 whereas for water-contact recreation it would be desirable to have a PI equal to 1.

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Using updated data with the benefit calculations provided by Faro and Nemerow (21) it has been determined that Onondaga Lake is presently "worth" $3.2 million less per year than if it were of a quality suitable for water-contact recreation. Thus the loss of benefits amounts to $8,800 per day.

The itemized annual benefits are as follows:

Water Use	Present Quality	Improved Quality
Recreation	$1,479,416	$5,194,856
Land Use	- 595,291	1,266,952
Wastewater Disposal	3,831,000	0
In-Stream	80,931	0
Withdrawal	300,000	1,095,000
Total	$4,334,194	$7,556,808

At this point it is necessary to relate the available data in order to establish a methodology for fulfilling the objectives as listed by Nemerow (19). The input data used by the writers in this part of the project in establishing a relationship are summarized as follows:

1) 123,000 pounds of oxygen consuming material discharged per day;
2) $8,800 of benefits lost daily at present lake quality;
3) average dissolved oxygen contact of the lake presently equal to 1.5 milligrams per liter;
4) average daily stream flow into the lake equal to 179 million gallons per day;
5) lake volume equal to 37,078 million gallons;
6) direct relationship between oxygen consuming material and dissolved oxygen concentration of the lake;
7) no loss of benefits when the discharge of oxygen consuming material is zero;
8) PI = 0 when the discharge of oxygen consuming material is zero;
9) dissolved oxygen of the lake equal to 8 milligrams per liter when the discharge of oxygen consuming material is zero;
10) minimum of 4 milligrams per liter of dissolved oxygen required in the lake (lowest acceptable for fish propagation);
11) a completely mixed lake;
12) PI = 5.4 at present quality;
13) PI = 1 as the objective (water contact recreation);
14) 470,000 pounds of dissolved oxygen presently available in the lake; and
15) 2.5 million pounds of dissolved oxygen available for sale daily under conditions of zero discharge of oxygen consuming material.

Figure 1 shows a possible relationship among these data. It is important to note that Figure 1 may not be an explicit relationship

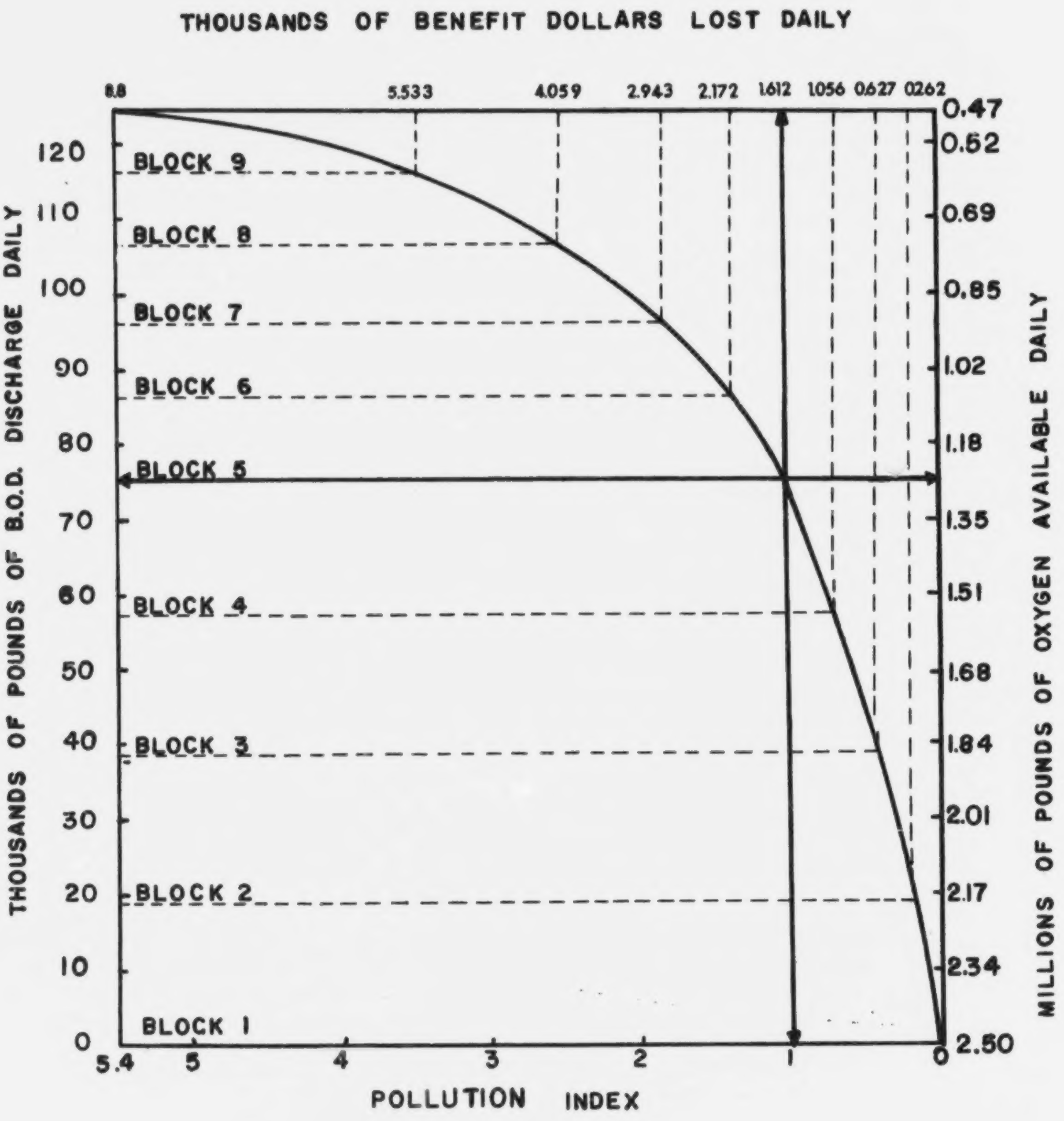

Figure 1. Unit Price Calculation

of the four parameters. It is known that there exists a relationship between dissolved oxygen and amount of oxygen consuming material being discharged, between oxygen consuming material and pollution index, and between pollution index and benefits lost. It is not unreasonable to assume, therefore, that there exists a relationship among all four parameters. The exact and precise graphical relationship may be difficult to illustrate, but Figure 1 can be substantiated theoretically and is suggested as a starting point for future studies.

The two end points are known to be essentially factual; $8,800 of benefits lost daily at the present discharge, and no loss of benefits when there is no discharge of waste materials. A third point was selected at the intersection of the two objectives, PI=1 and dissolved oxygen equal to 4 milligrams per liter. A curve is then drawn through the three points. The assumption of a direct relationship between dissolved oxygen and oxygen consuming wastes results in 1.25 million pounds of dissolved oxygen being available each day for a discharge of 76,000 pounds per day and still meet the established objectives for the lake. The remaining oxygen consuming contaminants must be removed by the individual dischargers by alternative methods than that of discharge into Onondaga Lake.

Having established the amount of resource available for sale the board will then have considerable flexibility in determining the price of the resource. As implied by the curve and stated in previous discussion, the suggestion is that damages (benefits lost) be used as the basis for determining price. Furthermore, it has been suggested that the principle of supply and demand be applied in such a manner as to discourage excessive waste discharges, encourage waste treatment and provide for efficient usage of resources. Assuming that the board is to be a non-profit organization with the sole monetary objective being to recover the benefits lost, it is possible to construct a sliding scale payment schedule. There are potentially many ways in which this can be done. One possibility is as follows:

a) Having established the objective, the board will be in a position to determine how much discharge will be permitted and the price to be cited for doing so. In the example being cited, 76,000 pounds of oxygen consuming waste will be permitted daily in order to achieve an objective of 4 milligrams per liter of dissolved oxygen in the lake and/or a pollution index of 1.0.

b) A decision must then be made as to how much of the 76,000 pounds will be sold at any particular price. For this example the author has selected to sell the discharge privileges in four blocks of 19,000 pounds each.

c) The unit price within each block is then calculated as being the incremental loss of benefits accrued by selling discharge privileges (See Figure 1) divided by the amount of discharge privileges being sold. In this manner Table II may be constructed.

TABLE II

Calculation of Unit Prices

Block	Pounds BOD Sold/day	Incremental Benefit Lost ($)	Unit Price per lb. (¢)
1	19,000	262- 0 = 262	262/19000=1.4
2	19,000	627-262 = 365	365/19000=1.9
3	19,000	1056-627 = 429	429/19000=2.3
4	19,000	1612-1056 = 556	556/19000=2.9

The amount of discharge permitted each customer would be a matter for the board to decide depending upon the local situation. The purchase quota may be prorated based upon four possible suggested methods:

a) percentage of oxygen consuming wastes;
b) percentage of flow;
c) relative value (taxes) to the community;
d) relative need or desirability to the community of a particular discharger.

While it is possible that any of the four suggested methods may be more applicable in a given locality, the author has selected the first method to demonstrate the use of the system. Assuming that all dischargers elect to purchase the maximum B.O.D. resources rather than treat the wastes, Table III represents an allocation of the oxygen resources.

Having purchased all they are allowed, the dischargers must then eliminate from the discharge the remaining oxygen consuming wastes. Discharge B then may find that rather than provide treatment to remove 28,240 pounds of organic wastes (38% removal), and pay $354,039 per year for discharging 45,760 pounds of organic waste, it may be less expensive to treat to a higher degree and purchase less. If this is the case, the allowable purchases unused by Discharger B would then be apportioned to the remaining customers. Any discharger is free at any time to discontinue purchases and install treatment instead, or make other suitable decisions relating to production which requires less purchases.

TABLE III

Dischargers Costs

Dis-charger	% of Organic Load	Block Size, lb.	Allowable Block Purchase, lb.	Total Purchase, Four Block, lb.	Total Daily Costs $	Total Annual Cost $
A	35.29	x 19,000	= 6700	26,800	*569.50	207,867
B	60.18	x 19,000	=11440	45,760	969.97	354,039
C	.26	x 19,000	= 50	200	4.24	1,547
D	.08	x 19,000	= 15	60	1.27	464
E	.08	x 19,000	= 15	60	1.27	464
F	4.11	x 19,000	= 780	3,120	66.07	24,115
Totals	100.00		19,000	76,000	$1612.32	$588,496

*6700 lb at 1.4¢ = $93.80; 6700 lb at 1.9¢ = 127.30, etc.

The board may for some reason, be it technical, political or economical, decide that purchases beyond Block 4 (76,000 lb.) may be permitted. While it may well be that the discharge of 76,000 pounds of organic wastes daily will not give exactly a PI = 1 and a dissolved oxygen concentration of 4 milligrams per liter, the discharge of much more than this may definitely impair the quality of the water. For this reason it is suggested that, if additional sales are to be made, a factor be applied which, when multiplied by the price per pound, increases the unit price sufficiently to discourage excessive purchases. The price will increase naturally due to the shape of the curve shown on Figure 1, but not rapidly enough to provide the discouragement being sought. The factor proposed is equal to the ratio of the dollar benefits lost at incremental blocks to the dollar benefits lost at the desirable level or objective. It is also suggested that the blocks be decreased in size to 10,000 pounds each to provide even further discouragement for excessive purchases. The results of having done the above are shown in Table IV, where the dollar benefits lost at the desirable level are $2,930 per day.

The board is in a position to sell resources once the unit prices have been determined. In a real situation the benefits foregone would be attributed to more that just oxygen consuming wastes. There would need to be a resources allocation for each contaminating matter deemed to be degrading the aquatic environment with the foregone benefits being prorated for each, so as to establish unit prices for each contaminant of a waste. The board then will have achieved the primary goal of maintaining some minimum acceptable water quality goal. In so doing, it has encouraged waste treatment by setting a "pollution price" based on benefits foregone, and have collected revenue, the uses and disbursements which will be discussed later in this section.

TABLE IV

Calculation of Increased Unit Prices

Block	Pounds Sold	Incremental Benefits Lost ($)	Price per lb. (¢)	Factor	Unit Price $/lb.
5	10,000	2172-1612 = 560	560/10,000=0.056	x 2172/1612	= 0.075
6	10,000	2943-2172 = 771	771/10,000=0.077	x 2943/1612	= 0.140
7	10,000	4059-2943 =1116	1116/10,000=0.111	x 4059/1612	= 0.281
8	10,000	5533-4059 =1474	1474/10,000=0.147	x 6633/1612	= 0.504
9	7,000	8800-5583 = 3267	3278/7000 =0.457	x 8800/1612	= 2.50

An Administrative - Regulatory Board

In the administration of a program such as the one being proposed, it is quite obviously out of the question to consider the state and/or Federal governments as the administrative body. The differences in economy (standard of living, industrial activity, etc.) from one locale to another would preclude an efficient operation by either jurisdiction. The application of general state-wide requirements for uniform treatment solely for the sake of providing treatment.

The proposed methodology is perhaps best managed at the regional level. It may be a river basin or portion thereof. This does not imply that the State or Federal Governments relinquish their responsibilities, but that their policies be implemented by some smaller unit capable of making better evaluations of regional needs and desires, as well as regional benefits of pollution abatement. The higher jurisdictions may still determine the minimum water quality upon leaving the basin, but the manner in which that goal is achieved and the water quality within the basin would be decided upon based on regional desires.

As stated by Kinney (23), "The answer (to pollution abatement) lies in a local team effort, the formation of conservancy foundations in river basins or portions of basins. The foundation would consist of counties, municipal corporations and industries...Such an approach provides positive leadership; it eliminates delay while arguments and uncertainties as to what the federal or state final decisions may be prevent other programs from getting underway; if it agrees with the State adopted standards it can proceed to assure their attainment; it provides an organization which can speak for the best interests of the basin and answer any charges by either Federal or State agency that the adopted program is inadequate."

"In short, it gets action started and places the burden of proof on someone else that the action is not in the public interest. It permits the citizens to achieve pollution control by joint effort, and if capably directed, this will be at least cost."

A local joing determination of alternatives, costs and benefits can do well in any court review. This information also makes sense to Congressmen and members of the state legislature."

Kinney's comments are worthy of considerable contemplation by legislators and pollution control officials. However, it is not the purpose, at this time, to defend nor refute the relative values of regional administration as opposed to state or federal authority. They are discussed at length by Kneese (24, 16), Martin (25), Deininger (26), and Fair (27). The response of one regional group to the proposal will be discussed in the following chapter. For the present it is to be assumed that the regional approach is acceptable and perhaps the only means of implementing resource sales.

Based upon the presumption of local basin administration the precise problems to be considered are who should be represented on the board, how large should the board be, how should the board be selected, to how large an area should the board's jurisdiction extend, and how should the board operate? It was originally intended to determine some answer to these questions but it soon became obvious that there would be no clear cut solution for every possible situation. Representatives on the board ideally should include one spokesman from every type of major water use within the jurisdiction: municipal corporations, industry, agriculture, recreation, navigation, etc. It perhaps would be desirable to have equal numbers of representatives in voting positions for each interest group, but then again there might be a logical argument for prorating members based on size, use, tax contribution, etc.

The number of members is likewise a matter of specific circumstances. The only point that can be made at this time is that the board should not become a bureaucratic monstrosity. There should be sufficient members to present as many opinions as may be necessary for equitable decisions. There should not be so many as to tie up proceedings in lengthy and perhaps useless debates. This is a problem, however, for which the author feels it is difficult to optimize a solution. A decision for the numbers of members can probably be made on the basis of economics. It is proposed that board members be salaried. Difficulties can arise, as noted in the next chapter, when such members are uncompensated. The salaried board member may not serve full time, but some compensation should be forthcoming for the efforts of such individuals. The board would need a full time staff of engineer(s), secretary(s), etc. The majority of operating expenses should be allocated to these individuals. Salaries for board members would ideally account for a minimal percentage of operating expenses but be sufficient to encourage honest efforts on behalf of the members. The primary objective would be to avoid understaffing or underrepresenting to the point where the efforts of the organization result in minimum benefits per dollar of operating expense. Large, self-serving bureaucracies are not the answer to the problems but neither is the other extreme.

Selection of board members is an extremely crucial matter in the efficient operation of such an organization. The Water Resources Commission currently selects members for the Local River Basin Planning Boards in New York State which are discussed in the next chapter. This does not appear to be a satisfactory method for providing local representation. Although perhaps not the best alternative, but a better one, would be for individual interest groups to select their own representatives for some staggered term of office. Staggering the terms would prevent the entire board from changing office at the same time and allow for some continuity of policy. By specifying the length of term, the affected parties would have some recourse for inadequate representation, which they do not have now, and which is discussed in the next chapter.

The members selected would not in the true sense be lay citizens but would have to possess some working knowledge of the direction and desires of local groups. They would not have to be engineers, economists or lawyers, but be able to converse with such people, disseminate the facts and make a rational decision. This, of course, will not always be possible, but should be the objective. The author is uncertain as to what effect political party affiliation may have in the operation of such boards, but it is certainly a potential problem worthy of consideration.

The areal jurisdiction of such boards is commented upon by Kneese (16).

"What constitutes a region in which interdependencies are sufficiently large to imply centralized management? Is it the Muskingum, the Ohio, or the Mississippi? A smaller region like the Muskingum would be more managemable, but there is no doubt that the consequences of water use within a tributary basin will be felt well beyond.

In each instance it must be determined what the interdependencies are and what area they cover. Then an effort must be made to delineate an appropriate management unit on this basis. The final solution probably can only be found through experimentation. In proceeding, it would appear wise not to delay action in heavily developed smaller and medium-sized basins while agreement on appropriate machinery for a larger region is being sought.

In practice it might not be desirable to incorporate all traceable interdependencies in a single managerial unit. Some decentralization can be maintained by permitting separate regional agencies to provide one another with inducements to efficiency. For example, a main-stem authority might treat a tributary under the jurisdiction of a separate agency much like an effluent out-fall by specifying a standard for waters entering the main stem and/or levying a charge upon the materials contained in such water. The charges or standards should in principle be set to reflect the incremental main-stem costs of damages, extra treatment, flow regulation, etc., that are attributable to the residual waste load carried by the tributary. In this way the tributary authority would have an incentive to take mainstem costs into account, even though they are not directly within its jurisdiction."

The Sale of Resources

Having solved the various problems of initiating a resource sales board, the daily operations and actual sales should amount to a relatively minor problem. The first order of business, if it had not already been done, would be a survey of the basin, or sub-basin, to determine waste discharge sources and available pollution carrying capacity resources. Coincidental to such a survey would be feasibility studies for various alternatives, at different objectives, and the benefits to be derived at each objective. Through a series of informational hearings, or perhaps even a ballot, the local beneficiaries would be informed of the alternatives, the costs and benefits, and an objective would then be established by the Board in behalf of the citizens.

The board, with all interest groups represented, would then construct a payment schedule as suggested earlier in this chapter and distribute to the dischargers a summary sheet stating the allowable purchases and unit costs within each block of resources to be sold. After allowing sufficient time for the dischargers to evaluate their alternatives, a sale date would be set and all dischargers summoned. The actual sale would then proceed as discussed earlier.

The board may wish, for the first year of operation, to sell at extremely low prices in order to evaluate how the program will function. At each successive sale the unit price could be increased until the foregone benefits are recovered. The frequency of sales would be a matter for the board to decide. They may wish to hold a sale annually, semi-annually, during low and high resource seasons, etc. This decision would have to be made known in advance to the purchasers. Utilizing the high and low resource seasons would permit flexibility of treatment plant operations and take advantage of a natural situation. Such an option is not now presently available. At present, the engineer must design for the 'critical' summer low-flow conditions only.

The installation of new waste producing industries has always posed problems to any community. It is not anticipated that the resource sales concept will in any way alleviate such problems but environmental control should be made easier. This can be illustrated by a comparison with current methods. If uniform treatment is required in a basin, all new industries in the basin will be made to provide the same degree of treatment. After a period of time, the receiving waters are again overloaded and the uniform treatment requirement then upgraded. In the meantime, however, the problem will persist.

A resource sales board would first have the opportunity to decide whether the new industry was even acceptable and/or desirable. If not, they may deny the right to purchase, or allocate only very little. If the industry is acceptable and/or desirable, the interest groups (Board Members) would have participated jointly in this decision, and would therefore have made some prior agreement regarding cost-sharing of the increased waste discharge. In any event, the regional beneficiaries, through the board, have maintained complete control over utilizing the resources available.

The operations would not end with the sale of resources. The water quality must be monitored as well as the benefit evaluations rechecked. The overall picture of benefits versus quality will constantly be changing, resulting in a varying price to purchasers at each sale. It will also be necessary to maintain surveillance over the dischargers. The payment of discharge fees will not in itself assume compliance, any more than present methods of waste treatment are assumed satisfactory.

It can probably be seen by now that the actual routine is very similar to that of existing state control agencies, with the following major exceptions:

1) Planning, development and management of regional resources are carried out entirely at the regional level;
2) All users are represented in resource quantity, price, and allocation decisions;
3) Arbitrary standards are not established but only minimum water quality standards adhered to;
4) Dischargers pay for resources utilized; and
5) The unit price for the use of the resource increases with its depletion.

Budgetary Considerations

The proposed board will not exist entirely upon funds collected through taxation. It will function essentially as a private corporation or public utility and be paid by users of its product. It will differ from governmental agencies, private corporations and/or public utilities in the following respects:

1) It will not have to play the annual guessing game of preparing a budget request for the coming year, hoping to get the funds, and having to spend them;
2) It will not necessarily have to continually grow in size in order to provide for a growing community;
3) Due to product limitations it will not have to continually expand in order to fulfill demands; and
4) It will not be interested in showing a profit at the end of the year.

The first year of operation may require catalyst or 'seed' funds from private grants, state and federal aid. Beyond this point the need for such assistance should either diminish or disappear. Funds are then secured through resource sales, part of which will come from municipalities using the resource. It may appear that this would impose an additional tax upon the citizens but this is not necessarily true. By localizing the management program there would be of necessity a decrease in the operations and sizes of state and federal agencies. Accordingly, there should be a decrease in the amount of tax dollars required. It is difficult to determine whether or not the taxes required for payment to the board would equal or exceed the anticipated decrease in state and federal taxes, but it appears to the author that there will be a greater return for each dollar spent.

The revenue collected should theoretically amount to no more than the benefit dollars which had been lost annually. From this revenue must come the necessary funds for salaries and operations. Any remaining funds may be utilized in any or all of the following ways:

1) Research pertaining to local problems such as shoaling, treatment studies, storm water, etc.
2) Development of recreational areas, marinas, so as to enhance the stated water quality level objective;
3) Subsidizing of desirable but needy installations; grants in aid, revenue reduction and debt retirement; and
4) Scholarships

Although the Board must make considerable effort, in essence all that is being done is accomplishing at the regional level, with regional funds, what is being attempted by the state and federal governments for larger areas.

SECTION V

A TEST CASE

It was somewhat evident right from the start that this research study could never really be verified practically without the sanction of many individuals and agencies. It was also apparent that approval at the State level would require considerable local or regional support and desire. For these reasons it was decided that the proposed allocation method would be presented to some local or regional group before any serious attempts were made to approach the State.

Several possibilities existed; the City of Syracuse, Onondaga County, the Oneida Lake Association, or any of a number of others. After considerable thought, it was decided to make contact with the Eastern Oswego Basin Regional Water Resources Planning and Development Board (EOB).

The reasons for selecting the EOB as a test case may be listed as follows:

1) The EOB was a duly authorized local board as specified by state legislation.
2) The EOB had been in existence approximately three years and by this time should be somewhat familiar with the problems involved in water resources planning as well as the terminology of the field.
3) The EOB represents a five county area, based on hydrological rather than political subdivisions.
4) The board members are selected by interest group; e.g. water supply, industry, etc.
5) Onondaga Lake, a lake (and its tributaries) for which there exists some benefit determinations, lies fully within the EOB jurisdiction.
6) The EOB has no regulatory powers and it would be of interest to know if they would want such and how they would be used.
7) The EOB appears to be, in most respects, the type of local board envisioned in the proposed allocation system.

The EOB is one of eleven local river basin planning boards operating in New York State. The legal authority for such boards is to be found in the N.Y.S. Conservation Law, Part V, and is discussed by May (28). Before discussing the reaction of the EOB to the proposal, it is essential that the legislated activities and composition of the board be briefly outlined. Although such boards are local in nature, and in fact are created only following petitions by local political subdivisions, the New York State Water Resources Commission exercises what is essentially complete control over the board's existence. As May (28) points out, "The Commission has complete authority over whether a board is to be created, who will be members of each board, what type and amount of personnel and technical services are to be provided, whether the final comprehensive plan is appropriate, and when the board will be terminated". Section 437 of Part V states that thirty days after the Commission has approved or disapproved of the final comprehensive plan, the board shall expire.

May continued by adding, "though intended to allow regionalization of water planning activity, the legislation does not insist on extensive direct citizen participation. Board members are picked by interest group and are usually well informed on the local water resource situation. However, the public has no control over these men, and should a member not represent his county or interest, there is no recourse for citizens. County involvement is minimal during operation of the boards". "A final ambigious statutory point is development. Although called planning and development boards, there are absolutely no development powers in the legislation. The boards help to determine policy, then must turn the plan over to other units for implementation. The Commission does not even have to follow Board recommendations for new legislation; the statute only demands recommendation of '...legislation to accomplish and further the planning and development program of the water resources of the State.' (Section 439)"

Preliminary meetings with the EOB chairman and the state staff engineer assigned to the EOB revealed some interest in the proposal and arrangements were made for attendance at one of the board's monthly meetings to make a brief presentation.

At the first meeting on 24 September 1969 the board was presented with the chronological events leading to the investigation, the purpose of the study, and a short discussion of current abatement methods.

The meeting was attended by only four of the seven board members, three staff engineers, and a number of guests. Although no questions were specifically asked of the board, it was anticipated that lively discussion would follow the presentation, due in part to the controversial nature of the subject matter. The discussion period, however, was quite disappointing. The questions that were asked emanated from guests rather than the EOB members or engineers. Needless to say, the lack of response was even more puzzling than a negative one would have been.

In an attempt to evaluate what had happened, the following possible contributing factors were noted:

a) The board members were not aware of current abatement methods and were unable to comprehend the magnitude of the problem.
b) They were aware of current methods but were unable to form opinions.
c) They were reluctant to speak due to the presence of state engineers.
d) The hour was late, the meeting room was hot and stuffy and the uncompensated board members had already devoted a long day to the board's business.

Comments made at later meetings indicate that the problem was due to the last item rather than apathy or non-understanding.

The discussion was closed with a request for a second presentation at which time the proposal would be discussed in greater depth.

At the close of the meeting the chairman, despite the non-responsiveness, expressed interest in what was presented, looked forward to hearing the full proposal, and hoped that a second presentation would be forthcoming at an early date. There was, however, no specific date established.

On October 17, six days prior to the board's next meeting a phone call to the staff engineer revealed that the board was not expecting a second presentation at the October meeting and that perhaps a presentation in December or January would be more in order. Within the hour, however, a phone call was received from the same engineer stating that the chairman did desire a second presentation at the October meeting. This seemingly insignificant event may be quite revealing with regard to the politics of local planning boards.

At the second EOB meeting on October 23 the seven members were asked several questions regarding a hypothetical local regulatory board. Prior to this, however, there was a recapitulation of the first meeting and a statement of objectives, as follows:

a) To regulate water resources at a regional level;
b) To decide water quality levels based on regional desires and knowledge of costs and benefits;
c) To sell resources for quality preservation and generation of capital; and
d) To use the capital for the conservation business.

A somewhat hypothetical situation was then described for the board members, consisting of the following presumptions:

a) A law has been passed which conveys to the board full regulatory powers over water resources within the Eastern Oswego River Basin;
b) Minimum water quality standards and treatment requirements have been established by the State and/or Federal governments;
c) The beneficial use of Onondaga Lake is the key water resources issue within the basin; and
d) The interest group representation on the board remains the same.

The EOB members were then asked questions regarding each of the above.

1. Concerning Their Role as a Regulatory Body

    a) Do you want to be such a body as described above and are there any specific objections to being such?

The board members were unanimous in their feeling that regional boards be given regulatory as well as planning powers. They went further to say that such a board should be composed of lay people and not professionals, that they did not want any state or federal representation in a voting position, that they would need a supporting professional staff, firm legal basis, and an approved plan upon which to base decisions.

    b) Do you, as a board or as individuals, feel the competence necessary to deal with the various types of problems facing regulatory bodies?

Again the members were unanimous in stating that they could function efficiently, with the stipulation that they would need a competent supporting staff.

    c) As a regulatory body, how far do you feel your jurisdiction should extend?

The members were in agreement that they should have authority over water resources activities within the basin.

2. Concerning the Establishment of Water Quality and Treatment Standards

    a) As a regulatory body given the primary authority you feel you need, what is your impression of the state and/or federal government establishing water quality and treatment standards?

Not all members responded to this question, but those who did expressed the feeling that the standards set by the higher authorities were not always rational and that a preferred method would be for such authorities to establish guidelines or minimum water quality standards for waters leaving basins, but that the manner in which the standards are met and maintained should be a matter for the regional basin boards to decide. They added that a knowledge of benefits and costs is necessary before deciding upon any abatement program, and that the local boards would be in the best position to make such determinations. In addition, they acknowledged that objectives and programs in bordering basins would have to be somewhat compatable but that this would be preferable to uniform statewide standards or requirements.

    b) Do you feel that you could meet minimum requirements, achieve basin objectives, and remain compatible with neighboring basin boards?

The members could foresee no difficulty in doing all three.

3. Concerning Representation on the Board.

a) Do you feel that the interest group representation is adequate?

They felt they had a good cross-section, and that no alterations would be required.

b) Is the size of the board in any way limiting?

The members expressed the opinion that one man representing each of five interest groups, as well as two at-large-members, provided sufficient membership for the areas in which they have been dealing.

4. Concerning Onondaga Lake

a) As representatives of the local water using groups, what is the desire for the future of Onondaga Lake.

Once again the members exhibited unanimity in stating that Onondaga Lake should be considered for use as water-contact recreation but for no higher quality water use.

b) Inasmuch as the lake is not now of such a quality, what information would be needed before making a decision as to whether or not it should be upgraded to such a degree?

The responses to this question were as follows:

1. If the recreation is the goal, we must determine if it can be achieved at any cost;
2. The willingness of the people to pay governs whether it should be done;
3. We need to determine the aereal extent of beneficiaries;
4. We must compare Onondaga Lake with others nearby and determine need for additional recreation;
5. A set of priorities is needed;
6. In addition to priorities, we need a set of various objectives and alternatives to each objective; and
7. We need the costs of each alternative and the benefits to be derived from each.

It can be seen from the responses that the board members are quite aware of the steps that should be taken before making a decision as important as this one is to the residents within the economic considerations, and not apt to make an emotional or irrational decision.

At this point in time the board members appeared to be quite excited about a situation that could easily have taken place, one which they could deal with given the essential facts. They began asking about costs of various projects and benefits to be derived. There were also questions about the manner in which the allocation proposal would be implemented.

It must be pointed out at this time that the principal investigators had not been involved in studies regarding the treatment of wastes entering the lake. They were, however, aware of two proposals which from only cursory review would have achieved essentially the same results; quality suited for water contact recreation. The first called for secondary treatment of domestic and industrial waste at a new treatment plant, while the second included provisions for the holding and subsequent treatment of storm water. The costs were $50 million and $150 million respectively.

This may have been a poor example because of the disparity of costs, but at the time they were the only two alternatives known. The important point, however, is that the board members felt the $50 million price tag to be too high. At 6 1/2 percent interest for 30 years the annual cost would have been approximately $3.8 million. The members were then made aware of the benefit determinations for Onondaga Lake. When informed that the annual benefits for upgrading the lake to water-contact recreational quality were approximately $3.2 million, over and above the annual cost of $3.8 million, their attitude changed completely. They now felt that the investment was worthwhile. The most significant comment was made by the chairman in calling for some method other than assessed evaluation to be used in raising the revenue. At this time the principal investigators were asked to return for the next board meeting on November 26 to present the allocation-pricing proposal.

At the third meeting with the board the members were first informed of the methodology used in calculating annual benefits. Following this discussion the members felt the benefits to be underestimated and the value of a clean lake to be greater than that reported. They were introduced next to the allocation-pricing scheme discussed in Chapter II. Time was not sufficient to permit them to fully comprehend all that went into the methodology but they were interested and intrigued at the proposal for the following reasons;

a) It utilized benefits as a means of charging for waste disposal;
b) It provided management with an easily administered program;
c) Contrary to other utility economics, it charged more for increased usage; and
d) It provided revenue for additional conservation efforts.

The members once again demonstrated an enthusiasm and were particularly impressed with the possibility of raising funds locally and utilizing such funds for park development, debt retirement, subsidization, etc. Most of the questions and comments concerned these matters. No objections were noted, and interest appeared to be high. Those in attendance exhibited an understanding of the concept about as well as could be expected for a one hour discussion. It should be noted that the meeting was attended by all the board members, several staff engineers, and one or two higher ranking state engineers at the regional or district level. Before closing the meeting the chairman asked for time during which he and the other members would discuss and digest the proposal, and that following this they would contact the authors.

On December 17 a letter was sent to the chairman thanking him and the board for their time and asking several questions regarding their response to the proposal. He was also asked if another meeting would be possible during which unclear issues would be discussed as well as future efforts.

A reply (29) was received dated February 9, 1970. In part the letter stated:

"I would be remiss if I did not indicate that I and my constituents were extremely impressed with the concept presented and note the forethought of you and your staff for the ingenious technique and proposal presented. We, as I am sure you are aware, are extremely interested in the application of a river basin authority such as you proposed which, I would suspect, has never before been implemented in the eastern United States. We, as a lay citizen board, can envision many of the far reaching implications of this mode of regulatory discipline to protect the future of our water resources in the Oswego River Basin.

The board at this stage of the planning process has not yet addressed itself, in specifics, to financial institutions or arrangements, implementation and administration. However, we are keenly aware of the problems, possibilities, and alternatives to accomplish the development of our planning efforts. We would appreciate your attendance and presentation at our February 25, 1970 meeting (executive session) to answer some specific points of concern to the members as I sense we are not yet fully prepared to answer the questions you have posed. A list of these specific points is being completed and will be forwarded to you prior to the meeting".

The meeting was attended on February 25 without having received any such list. The whole board, staff engineers, and the same higher ranking engineers mentioned at the previous meeting, attended this meeting. No formal presentation had been planned for this meeting except to request the board, if they felt the proposal had merit, to approach the Water Resources Commission with the possibility of utilizing the proposal for a one year trial period. The following feelings were then expressed:

a) Several board members said they did not understand the proposal;
b) The proposal was too complicated and innovative for them to comprehend it;
c) They did not want to approach the Commission but saw no objection to the principal investigators doing so;
d) State engineers felt that the lack of knowledge concerning the dynamics of lakes precluded using such a methodology;
e) Perhaps another lake would be better suited than Onondaga;
f) They didn't know what was expected of them; and
g) The staff engineer felt that the proposal was a viable one but in view of current events concerning the Commission he did not feel it was wise to approach them.

This last comment pertains to the fact that the Erie-Niagara Board, one of the other local boards, had already finished their planning stage and was at that time making a strong demand for creation of regional development boards. Similar in every respect to the local planning boards, they would play a major role in plan implementation. The Water would play a major role in plan implementation. The Water Resources Commission is obviously faced with a problem of establishing a precedent upon which the other local boards may build a case. At the time of this writing, the issue had not been resolved.

Despite there having been no strong objection to the proposal, the comments of the board were rather startling. Their attitude, enthusiasm and interest had completely reversed and they appeared to be opposed to the concept for no apparent or spoken reason. Further discussion was out of the question but a final request was made that the board arrange for a meeting between Commission personnel and the principal investigators. This they agreed to do.

A follow-up letter was sent to the chairman within the week following the board meeting requesting that an appointment with the Commission be arranged as soon as possible due to the time limitations of the research contract. No such meeting has been arranged.

A meeting did take place, however, in May, 1970 between the board chairman and a consultant to the research project. It was an informal conversation meant to determine what had changed the board's attitude. The following comments by the chairman are taken from that meeting (30):

a) The board is a body of non professionals in water resource management who are unpaid, overworked, and lack the time to read pertinent materials or attend meetings.

b) The board is not an "action" agency and he doubts if they really want to be.

c) Changing the board would require State action which involves lengthy delays.

d) No one on the board has the desire to be activist.

e) The board tends to be powerless, non-grasping and non-desiring.

f) Onondaga Lake was a poor example due to there being too many vested interests, the lake being a special province, and the fact that it lies entirely within one county.

g) The proposal was too new, strange and different.

The chairman also stated that one of the board members had mentioned a system of charges being used on the West Coast. He said he would talk to that member, raise the question once more with the board, and then notify the authors as to the possibility of further negotiations with the board. As of August, 1970, there has been no contact with the EOB.

An evaluation of both the EOB and the meetings with them may be summarized as follows:

a) The board members, through informational meetings, guest speakers, etc., possess a working knowledge of the regional water resources picture.
b) The EOB, by statute or necessity, appears to be more interested in matters of water supply, conservation and flood control than in pollution abatement.
c) The members are apparently aware that certain problems exist in the matter of pollution abatement, but evidently are not close enough to such problems to identify and evaluate them.
d) Through an evolutionary process or by following the example of the Erie-Niagara Board, the EOB has some interest in plan implementation by regional units.
e) The EOB accepts the proposed methodology as a means of administration but is not prepared to be the prime movers in obtaining the enabling legislation.
f) The structure of the EOB as a local river basin planning board does not allow for an effective means of plan development and implementation.

One responsibility of the EOB is to study and investigate the use of water resources within the basin. The board has apparently done this by virtue of guest lecturers at monthly meetings. Through this exchange of information the EOB is to become familiar with the present and future problems of basin problems. It was the observation of the investigators, however, that individuals on the board were being courteous rather than interested, unless the topic concerned a problem from within their area of representation. During the meetings attended by the investigators the topics covered items such as water levels in the Barge Canal, shoaling of Oneida Lake, potential reservoir sites in the vicinity of Auburn, N.Y., etc. These were of such a local nature so as to potentially lose the interest of representatives from other areas. A subsidiary problem is the fact that the solutions to the problems being discussed may only be applicable to that particular problem and not to similar ones in the basin.

The discussions on the proposed methodology stirred up considerably more interest than other topics heard. It is not clear, however, whether the interest was aroused due to the new concepts being presented, or to the potential for having a "solution" for the entire basin, or both. Many comments and questions were received from each member, an event unwitnessed by the investigators at other presentations.

During the course of the meetings water pollution was a topic that remained virtually unmentioned. It was apparent that the members have not been deeply involved with matters of water quality control. The enabling legislation for the EOB does not specifically refer to water pollution but does call for the planning of the water resources uses for the maximum benefit of the people. If the restriction is placed on the term "water resources" so as to include everything but quality control, it is doubtful that plans for development can be consistent with maximizing benefits. The EOB presents a plan for water resources development and a second agency is in the meantime doing the same for quality control. It is not a foregone conclusion that the end result will be incompatibility, but it is a strong probability.

Throughout the series of meetings with the EOB there were definite statements, as well as subtle hints, that the board felt that plan implementation should be carried out by the same or similar boards responsible for the plan. Several members exhibited their belief that development and enforcement would be better handled by a regional agency relatively free of political constraints. At least two members were emphatic in stating that regional boards would be better suited than state or federal agencies and that there should be no state or federal representation on such boards. On this last point the authors disagree in that representation by both, at least at a non-voting level would be desirable in order to assure compliance with policies and standards, approach compatibility with contiguous basins, and keep the board aware of financing programs. The attraction for regional boards, however, is supported by the authors.

It is uncertain to what extent the EOB is willing to make their feeling known to higher authorities. There was no reluctance to express their opinion until the last meeting. At that time, in the presence of New York State engineers other than the assigned staff, no support for such boards was heard from the members. The investigators left the meeting with the feeling that external pressures were exerted on the board to discontinue negotiations. This is an unfounded belief, but certainly one which cannot be discounted. The complete reversal of the board's support remains unexplained.

Mention was made of the efforts of the Erie-Niagara Board to secure authority for a regional implementation agency. It was also stated by the staff engineer, that this effort was creating somewhat of a turmoil with the Water Resources Commission and that a proposal such as the one being discussed, although "viable and interesting", would at that time only lend to the confusion. The board members, in addition to doing an 'about face' appeared to be upset about something. The formality and relaxed atmosphere present at earlier meetings were completely absent. Nothing conclusive can be drawn from this except that it supports the theory of external pressure having been applied. This belief is strengthened by the total lack of criticism concerning the proposed methodology. There is little doubt that the proposal was acceptable to the EOB members. Complimentary comments, exuberant suggestions, and requests for more information lead to this conclusion. No criticism was received at any meeting. The reasons for their interest and acceptance have already been noted. In view of the stated reasons, answers to questions asked of the members, and lack of reasons for not pursuing the project, the investigators are again led to the conclusion that it was not the decision of the board to discontinue further efforts. This belief is strengthened further by a comment made by the Chairman of the EOB when asked if the board would support the investigators in presenting the proposal to the Water Resources Commission. He indicated that this has already been done. No additional explanation was offered and the manner in which it was said implied that none was needed.

The position of the EOB, as well as other such planning boards, relative to existing state controls is questionable. The absence of board authority, when considered with the State's complete control over the board, casts doubt on the success of such a structure. Some of the shortcomings of such boards have already been discussed by May (28). In addition board members are uncompensated for their efforts. This may not be a severe problem but certainly provides little incentive for maximum efforts on the part of the board members. This should not be construed as criticism of individual members, but of the manner in which the boards are made to function.

Board meetings are held monthly. At the meetings, which last for only a few hours, the members are informed of the staff's efforts during the preeding month. In other words, the members have very little exposure to the many issues, and then for only a short period of time. As indicated by the Chairman, the members have little contact with board activities outside of the monthly meetings. The reading of pertinent printed matter is probably at a minimum due to outside interests and lack of compensation.

It is the opinion of the investigators that the EOB is fortunate in having assigned to them a very competent, clear thinking staff engineer. This is brought out due to the fact that the staff engineer for such boards is probably the one that dictates the direction taken by the boards. The brunt of the work falls upon him and his subordinates. He in turn makes reports to the board and suggests courses of action. Inasmuch as he is a state employee assigned to the board, his thinking is apt to coincide with that of existing state policy. This can be acceptable or not, but may tend to dull imaginative and innovative actions taken by the board members. There can be no question that a chairman could be greatly influenced by the staff engineer. This potential problem, as real as it may be with other such boards, was not demonstrated to any great extent by the EOB.

The local river basin planning boards are examples of the efforts to establish "home rule" with regard to water resources. The concept is admirable, and desirable in the mind of the author, but under the current legislation it is doubtful that such boards will serve to be any more than "social pacifiers". The criticisms to be found with them outweigh by far their advantages. If there is some doubt concerning their abilities as useful planning boards with the constraints presently placed upon them, there can be no doubt as to their future as development or regulatory boards. The removal of these constraints, in combination with needed legal revisions opens the door for what could be very effective regional authorities.

SECTION VI

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SECTION VIII

APPENDIX

Since regional environmental management appears to be ideally suited for efficient and equitable pollution abatement and since it also can be evidently extremely difficult to initiate, we encouraged our consultant to contribute an appendix to this project. The appendix is entended to provide the reader with basic operational fundamentals of environmental management at all levels of government. From an evaluation of this the reader may be able to draw his own conclusions for pollution abatement administration.

ENVIRONMENTAL MANAGEMENT AND LOCAL GOVERNMENT by
Roscoe C. Martin

1. Environment, Natural Resources, and Public Action

Environment is everything, everywhere. One dictionary has it as "The aggregate of surrounding things, conditions, or influences". Since this carries no limiting word, one would be hard put to imagine a more inclusive definition. More concretely, one might view it as the natural physical system within which life endures, except that life itself (more specifically all living things) is part of the environment. But since a vantage point must be established from which to view the environment, let that vantage point be man himself. From the beginning of time, men have assumed that the environment exists solely for the benefit of their kind, and have conducted themselves accordingly. It would seem late in the day to attempt to change the fundamental focus of all recorded history. Let us therefore modify the dictionary rendition to accord with that central focus: the environment is the aggregate of resources required for the maintenance of human life.

Here a new element enters into the discussion: resource (or resources). A resource may be considered to be a commodity, thing, or attribute which is or which may be made available for human use. Since the environment exists without reference to time, place, or technology, it would seem proper to limit the concept to natural (as opposed to man-made) resources. A natural resource is a resource which exists (or which may be summoned into being) as a bounty of nature.

The basic natural resources were long held to be water, land, and forests; air--atmosphere, oxygen--was taken for granted. To these three "basic" resources minerals and fuels came to be added in time. Subsequently sunshine and precipitation, that is to say climate, and inferentially the growing season, were added. Current emphasis is on water (as throughout human history) the atmosphere space and the ocean. As a final and over-riding resource may be mentioned people who, primarily users (sometimes abusers and even destroyers) of resources, are themselves a basic element in the environment. Natural resources thus broadly conceived (and the list is undoubtedly incomplete) would appear to be all-inclusive of the elements essential to human life, and so to warrant

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identification with "the environment". The trend toward amalgamation of the two concepts is seen in the recent call for establishment of a national department of resource environment. If this title adds anything to the familiar concept of a department of natural resources, it is to make that concept more all-embracive. Those who talk about the environment are therefore talking about natural resources broadly conceived.

The history of mankind is one of unremitting effort to make the environment more supportive of the purposes of man. Man's utilization of the resources of nature may be said to have under-gone five stages. The first was that of simple and straightforward use. *Use*, however, often led to a second stage, one characterized by *misuse*. The consequences of misuse were several. Among them may be mentioned, as a third stage, depletion. The *debasement* of resources marked the fourth stage. The ultimate result of the process of debasement comes with the *destruction* which marks the fifth and final stage of man's use (and misuse) of the environment.

The process by which acceptable resource use degenerated into misuse, which in turn led to the depletion, debasement, or (sometimes) destruction of natural resources, passed unnoticed for a very long time. For one thing, the resources seemed inexhaustible; for another, the people using them were comparatively few and widely scattered; for yet another, the American doctrine of laissez faire countenanced individual and corporate exploitation of the resources virtually without restriction. Thus the five stages of resource utilization identified above were not perceived as a contimuum, and the profligate use of natural resources was justified in the name of human progress.

Of recent years the national mood respecting resources has changed dramatically. Familiar and long-accepted evidences of resource abuse--soil erosion, smoke and ash in the atmosphere, the degradation of fresh waters through domestic and industrial waste--have become objects of widespread and highly vocal criticism. Scientific advances have led to new and strange assaults on nature--atomic pollution, sonic booms, dangerous concentrations of mercury in food fish--which have given added cause for public clamor. Scientific advances have also led to interesting and sometimes curious modifications in official (and popular) comprehension of the defilement of nature and consequently to drastic turnabouts in public policy: DDT, but recently hailed as the agent which had made possible the eradication of malaria throughout much of the world, now faces a world-wide ban as to poison inimical to human beings as well as to mosquitoes.

"Environment" a short five years ago had a precise meaning among the relatively small number, mostly scientists, who employed the term. Once a noun which stood for a wholly respectable concept, it is now used adjectively--environmental pollution, environmental contaminant, environmental noise, environmental destruction--to describe practices and actions and results regarded as anti-social. Pollution, defilement, destruction: these are the words currently most frequently applied in discussion of the environment, and the greatest of these is pollution. The automobile, operating essentially as it has since the beginning of the century, becomes, through growth and concentration of both cars and people, a prime polluter of the atmosphere; a music festival finds itself indicated as a multiple polluter; a youngster setting off a firecracker is guilty of noise pollution. Pollution, like environment, is everywhere and very nearly everything. Considerations of health and safety, together with an emerging ethic fired by a revolution in public sensibilities and expectations, demand drastic action. What is required is the elimination of, or at the least a substantial abatement in, pollution over a wide front in the interest of preserving (or restoring) a livable environment.

If the intensity of public concern for the environment is a recent phenomenon, a gradually growing interest in the subject is not; for there has been an increasing public awareness of the significance of the misuse of natural resources for society for more than half a century. To emphasize this growing public concern is not necessarily to denigrate private action toward the suppression of pollution. Many private enterprises have indeed made significant efforts toward upgrading the environment (or that part of it with which they have been primarily concerned), or at least to avoid its further downgrading. Major efforts nevertheless have been public--that is to say governmental--in character. The time appears to have arrived when there is something approaching a consensus calling for vigorous governmental action looking toward the preservation of the nation's remaining resources, their restoration to full health where that proves practicable, and their wise use (to the extent possible) in the future. In short, the time for more positive action by government appears to be at hand. That at any rate is the bias of the writer, and that is the premise which underlies the remainder of this essay.

The current emphasis on the urgency of the problem of environmental pollution/destruction, on the national emergency precipitated by recent developments, and on the urgent need for immediate and drastic action if the environment is to be preserved in a form compatible with human life--in short, the growing sense of national crisis, tends to obscure the fact that the country has been concerned with the use and abuse of natural resources, and so with "the environment", for a great many years. During the first hundred years of the last century, and more audibly during the first years of this century, the voice of the conservationists began to be heard: let us use our resources more wisely, let us consume them with greater restraint, let us eliminate waste to the extent practicable, let us preserve the bounties of nature for future generations. A second major shift in the public's attitude calls for positive action looking toward the management of natural resources. With each passing decade the role of government has become greater: individual and corporate role of government has become greater: individual and corporate license to exploit the resources has receded gradually before a mounting sense of public proprietorship, and more and more laws have come into being to govern the use (and suppress the misuse) of resources, more and more administrative agencies have been established to represent the public concern for more rational resource management. It may be granted that government has (governments have) acted in a haphazard, unplanned, often illogical manner in its efforts (usually ad hoc) to deal with the problems it has perceived, and that the net result is a far-from-effective instrument or plan for the public management of natural resources. That, however, is another story, one which, however important, is not relevant to the central theme of this essay.

The methods of government in natural resources administration run the gamut from service to private enterprises (to which almost no one objects) through education, research, advice and information, standards of performance (with or without attendant inspections) regulation, taxation (to produce revenue, to provide incentive, to regulate), financing private development, contracting with private enterprisers for the performance of selected services, negotiating agreement among interested (and frequently contending) parties, public-private partnership, technical assistance (to both private and public agencies), inter-governmental fiscal transfers to, ultimately, direct administration through public ownership and operation (to which many object). Even casual scanning of this listing will reveal that the activities of government respecting resources administration rnage from those generally accepted to those frequently attacked as "socialism". It will suggest too, that governmental activities cover a very wide spectrum, that virtually all governments are involved (some, granted, in a quite limited way) in resources administration is an exceedingly varied and complex undertaking.

Contemplation of the major aspects of public resources management immediately, and of course quite properly, raises the question, what governments are, and what governments should be, involved in the process? Resource management activities vary from boring a village well (and ascertaining that the water it produces is potable) to research on the methods and effects of disposing of atomic wastes. It is clear that governments of various kinds and at all levels not only are but inevitably must be involved in activities of so wide and varied a character. It is equally clear that such involvement must be selective. The central problem is to determine which government (more accurately, in general terms, which level of government) is best suited in such terms as vantage point, fiscal strength, technical competence, and leadership potential, to undertake responsibility for a given--and carefully delineated--part of the action. Appraising the contributions which each of the various kinds and levels of government is prepared to make to the total task of natural resources management is a task far beyond the scope of competence of this essay. It may, however, be possible to survey one kind of government with emphasis on its strengths and weaknesses as a role player in the emerging assault on environmental pollution and polluters. The remainder of this paper will be devoted to an appraisal of local government as a participant in the war on pollution.

2. Local Government: An Overview

Americans glorify local government. In its origins, local government was local indeed: it was small and folksy, it was close to home, its few employees were friends and neighbors, it was highly visible, it rendered minimal services which nearly everybody considered necessary. It savored of the grass roots. It was, moreover, indigenous, in that it was locally established in response to locally felt needs. By the same token Americans distrust bigness in government, whether defined in terms of geographic size, number of employees, size of budget, or number and variety of functions performed. By tradition, our sympathies and our (nominal) loyalties lie with the rudimentary governments of a by-gone day.[1]

Given this predilection, it might logically be expected that wide responsibilities would be placed on local government in the intensified attack on pollution which appears to be taking shape. Some proposals looking in that direction have indeed been made already. But before placing great faith in local institutions as effective combatants in the emerging wary, it would be well to appraise the capabilities of local institutions in respect of the heavy new demands that could be made upon them. Something more than sentiment will be required if the obligations of effective pollution control are to be met. "Keep government close to the people", "only at the local level can true democracy prevail", "those who enjoy the benefits of pure water (as an example) should pay for them"--as political weapons these slogans have their values; but their symbolism would appear to have little connection with the operational effectiveness of local institutions.

What kinds of governments does the term "local government" embrace? The most recent Census of Governments reports that, in 1967, the United States had 81,299 units of givernment. All but 51 of these (the government of the United States and those of the 50 states) were classified as local governments. Of these we may rule out townships, which normally perform only limited functions, and school districts, whose operational responsibilities generally have little to do with pollution control. What are left then are counties (3,049), municipalities (18,048), and special districts (21,264) a total of 42, 351 units of government which have (or may have) responsibilities relating to natural resources. Many of these units would seem to fit the nostalgic pattern of "little government" described above: 275 counties have less than 5,000 people each, over half the municipalities (54 percent) have fewer than 1,000, and 60 percent of the special districts have no full-time employees and almost as many have no debts. On the other hand, 107 counties have populations of 250,000 or more (all together have almost 44 percent of the population served by county governments); 130 municipalities with more than 100,000 people have (again) almost 44 percent of the population served by incorporated places; and 1148 of the special districts (over 5 percent of the total) have more than 20 full-time employees each while 2020 (almost 10 percent of the total) have debts of more than $1 million.[2]

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[1] The author has written on this subject in other places. See especially Roscoe C. Martin, Grass Roots (University, Ala. The University of Alabama Press, 1957).

Clearly "local government" is a thing of extremes. Clearly little can be realistically expected of the mini-governments described here. More may legitimately be expected of the larger and stronger units. Most of the larger counties and all of the sizeable cities are involved already in resources administration in one way or another; while almost half of the special districts are directly concerned with natural resources -- soil conservation, drainage, irrigation, flood control, water supply, sewage disposal, and so on.

It has been suggested that one of the prime characteristics of local government is its variety and complexity in kind, nature, functions, and strength. The municipalities range from villages with few or no employees or functions to New York, Chicago, and Los Angeles, the counties from small and elementary entities to centers of metropolitan government, the special districts from paper units to the Metropolitan Water District of Southern California. The extreme diversity in size, responsibilities, and fiscal resources among these 81, 248 units of "local government" requires caution and discrimination in use of the term. Some are indeed local in the traditional sense of the term--in the sense, that is, of Lilliputian government "close to the people"; some, on the other hand, are great and powerful and extremely diverse in functions performed. These are local only by designation. It is safe to say that much of what is called local government is irrelevant to present-day needs through deficiencies in scale and resources. Much of it, however, and specifically the larger and stronger governments, is highly relevant. This evaluation applies specifically to the family or activities and we have chosen to lable "environmental management".

Notwithstanding their extreme variety and diversity, local governments share certain common characteristics which are important to the present discussion. These may be said to be three in number. First, all are legally dependent upon the states, not only for the powers they exercise but indeed for their very existence. It is true that over the course of many years the states have come to be regarded as primary. The states exercise legal powers of life and death over their local governments, with political considerations the principal guarantors of local hegemony. This means among other things that local units, whatever their size and scope and strength, are governments of limited powers; it means too that the geographic area over which they have jurisdiction is carefully circumscribed by law.

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[2] United States Bureau of the Census, Census of Governments, 1967, Vol. 1 Governmental Organization (Washington: U.S. Government Printing Office, 1968). The data on which the above summary rests are to be found in pp. 1-5 of this report.

It is difficult to over-emphasize these points in assaying the role of local governments in protecting and restoring the environment.

Second among the characteristics held in common by local governments is their traditional role as supplier of services. Before there were states there were communities operating schools, building roads, and keeping the peace. Local governments still fulfill this historical need, though of course in widely varying degree. Equally to the point, they are expected by the people to act as purveyors of services. Here the myth lingers on even where the substance has largely evaporated. Even so the myth remains strong, and local governments are committed to its perpetuation. That the expectations are frequently frustrated in shoddy performance is part of the price paid for our excessive loyalty to government at the grass roots.

That price is further increased by the jealousy of their rights and prerogatives held by local governments: that is to say, by local officials. Communities of all shapes and sizes insist on their ability to deal effectively with whatever problem may present itself. No matter the nature or complexity or point of origin or pervasiveness of impact: pollution of water, air, and soil is clasped to the bosom of the community as a local problem. Offers of "outside" help are viewed with suspicion, non-indigenous individuals and institutions as intruders. This sense of self-contained competence leads to the practice of exclusivity: to residence requirements for candidates for local office, to the doctrine (and widespread practice) of "hometown boys for home-town jobs", to note two common examples.

The doctrine of local self-sufficiency, together with its consequent introspectiveness in the practice of administration, results in a certain churlishness on the part of one local unit toward another, or, indeed toward all others. If a government regards itself as able to serve local needs and solve local problems through employment solely of its own resources, what is the need to seek the assistance or even the cooperation of other governments similarly placed? Considering that neighboring governments entertain identical views of their own positions, rights, and strengths, what indeed is the promise of interlocal mutual assistance or cooperation? Herein lies one of the most serious obstacles to the attack on public problems through pooling of local strengths. We shall have cause to return to it presently.

It will prove useful at this time to examine the question of local governmental adequacy in the face of the mounting complexities of public problems. A government is called into being, and it exists, for the sole purpose of serving human wants and needs that would not otherwise be met. It is a truism that local governments are increasingly helpless to cope with the problems of modern technical society; some observers argue, indeed, that local government as presently constituted is largely irrelevant to the emergint proglems of congestion, crime, poverty, and pollution. We need not go so far to agree that local governments do not hold high promise as potential contributors to the coming war against polluters and pollutants of the environment. Examination of a few criteria of local governmental adequacy (or relevance) will enlighted the argument.

First is the criterion on areal adequacy. A given unit of local government was established to discharge one kind of responsibility, but later finds (or may find) itself confronted by quite a different kind. Geographic area and function, once reasonably congruent (though never perfectly so) may now find a serious want of congruity in important areas. Smog drifts and water flows, and the contamination of either air or water may be offensive (even dangerous) to neighboring communities of recent growth. How render a local unit adequate, in terms of simple geographic reach, to the new responsibilities of environmental management? The way is long and tortuous, but a shorthand answer may be offered: no very effective way has been found.

Second, local governments enjoy only such powers as are granted them by the states, as noted above- The powers of a particular unit may or may not be sufficient to permit it to cope with the emerging problems of pollution abatement and control. The chance is good that they will not be adequate, for the states generally have been niggardly in the powers they have bestowed upon local governments. And the simple grant of legal powers is only part of the story of state-local relations; there are many state-imposed limits and regulations which affect local capabilities (Sometimes for the better, often for the worse) to meet new and different requirements.

Third, a local unit develops its own operating style over a period of years. It establishes its own routines, its own precedents, its own sense of a proper and fitting course of action. The setting of rules and of agreed limits of action is of course necessary to orderly operation, but it may also inhibit adaptation to new and unanticipated problems. It develops therefore that a local government's customary manner of operation is a limiting factor in its consideration of ways to approach new and complex problems. A government which has found no need to seek outside assistance and which has had no experience of intergovernmental cooperation is not likely to view with enthusiams the prospect of inter-local action.

Fourth, a local unit may or may not have the resources to deal effectively with a new service demand. Such resources may be, first, financial in nature. Many local governments probably are poverty-striken; they neither have nor claim to have, nor indeed do they seek, fiscal resources of consequence. Those which do--the larger and stronger governments--are without exception in financial straits; many indeed claim that they are facing bankruptcy, though it is not recorded that any of the major cities or counties have actually "gone broke". Here may be noted the single important exception to the above-noted rule of local introspection: local governments gladly swallow their pride--it proves not too large a lump--to accept financial assistance from any and every "outside" source, and particularly from the state and the federal governments. Even so local governments in general, even the larger and more prosperous ones, face an uncertain financial future. It is difficult to see how any local unit, or even any prospective consortium of local units, could command sufficient financial resources to mount a general attack on contamination of the environment.

Aside from money, a local unit's resources may be appraised for their technical strength. Here local government would seem to be in sounder condition, in that many local units have well-trained technicians. The strengths may be more illusory than real, however, for the science of environmental management requires insights and skills which may be quite beyond the grasp of the traditional chemist or engineer. It may be, indeed, that long experience as an engineer in city or county government will turn out to be a positive disqualification for public service in the new environment-conscious society.

Next, the political viability of local governments, and of individual local governments, is a legitimate criterion for mention here. By this is meant such considerations as demonstrated ability to serve the public, the capacity for identifying and dealing with new and strange problems, and skill in relations with other governmetns--local, state, and federal. A Government which has earned a reputation for plodding administration of half-measures in normal times is not likely to be, or felt to be, an effective participant in the developing war on pollution.

Finally, inseparable from the criteria examined to this point is the element of leadership. Leadership in this context may be said to embrace the abilities to discern future developments, to appraise their probable impact on government, to identify alternative courses of action as responses to the emerging demands, to energize the organization available and to devise a new structure as necessary, to lay out a course (or courses) of action from the alternatives identified, to enlist support whereever it can be found (including of course, support by other governments, particularly state and federal governments), and to rally public support to the end that government action may become community action as well. The old-time political leader served many useful purposes (as we-l as some destructive ones) in his day. The call now is for leadership which will combine the synthesizing skills of the politician, the prescience of the prophet, and the tact of the diplomat. It is obvious both that local government has produced few such leaders in the past and that very few are engaged in practice now. The description nevertheless depicts the ideal. To the degree to which local leaders are able to combine these several elements of ideal leadership, local governments may hope to play meaningful roles in improving and restoring the environment.

3. A Role for Local Government?

Let us turn now to examination of the possible significance of these ruminations for local government participation in environmental management. If resources administration on the one hand and local government on the other are as varied, uneven, and complex as we have found them to be, then the problems to be encountered in marrying the two in a way to bring about operational effectiveness and programmatic achievement may be expected to be complicated indeed. Not that local governments and natural resources are strangers. On the one hand local units are themselves among the most wanton polluters, both through direct contribution of pollutants and through toleration of pollution by industry; while on the other hand such governments, particularly municipalities and special districts, have participated positively in resources administration over a great many years. There are, for all that, both new problems and emerging public expectations which justify question of local government's capacity to contribute materially to the new style of environmental management which will be required to meet the perceived crisis.

It has been noted that the energies of all governments at all levels must be engaged in reasonably coordinated action if the nation is to deal with environmental deterioration with anything approaching success. To lay out the issues and examine the problems involved in any such total effort is beyond the pretensions of this essay. Let us instead select a modest segment of the whole problem--one nevertheless of fundamental importance--which has direct and primary consequences for local government. The particular problem chosen concerns the long-continued but mounting pollution of a small intrastate river which, draining an area of approximately 900 square miles, flows through three counties, a city of 100,000 a city of 50,000, and a city of 10,000 on its way to join the waters of a larger stream. The basin also has 10 villages of 500 to 2,000 located on the main stream and on tributaries. The cities and several of the villages have used the stream for both water supply and sewage disposal for many years. As many as half-a-dozen industries, most of them small but nevertheless potent in local affairs, use the stream for waste disposal. Vested interests and uses are therefore strong. The time has come when they are also in conflict. There is a growing feeling that "something has to be done".

The problem is to cleanse the stream, first through control of polluters, second through abatement of existing pollution.[3] The local governments of the area are looked to for the necessary action. Even casual contemplation of the problem will suggest the nature of the action required for its solution--or, better, its melioration, since, given the number and nature of the parties involved and the longstanding uses they have become accustomed to make of the stream, a once-and-for-all solution is scarcely attainable. Action must be basinwide if it is to be effective: it must take into account, as nearly as possible, the needs of all the people in the drainage area. The bulk of these needs, though certainly not all, may be expected to be represented by the various organizations of the valley. As identified above, these include three counties, three cities, and 10 villages on the public side. The six industries also represent needs, and perhaps more to the point vested interests, which must be taken into account. The discussion here, however, centers on possible action by the 16 local governments of the basin. The assumption is that local public action is paramount, though in the end it may prove not sufficient.

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[3] Other potential interests in managing the river--for control of floods, irrigation, hydroelectric power, recreation, and so on--are deliberately ignored in favor of emphasis on the single issue of pollution control.

The cardinal point to be emphasized is that no existing local government will prove adequate to the task of controlling and abatine pollution in the stream. Nor, indeed, can any single local government now in being be made adequate to that need, given the law and practice of American local government. Local units have been granted limited extraterritorial jurisdiction--that is, have had their legal limits expanded to deal with a speficied problem--by state authorization here and there; but nowhere, so far as is known, has such a government been granted the extended jurisdiction that would be required for effective action over such an area as that described above. If the 16 local governments are to play a significant role, therefore, they must seek the capability for such action through agreement among themselves. In its simplest form this would entail appropriate action by other units, to clean up the river: that is, primarily, to reduce its own contribution to seek to persuade (or to force) local industry to suspend or abate its pollution activities. Something undoubtedly could be accomplished through this most elementary of common action by local units, but it is highly unlikely that such piecemeal action would achieve really significant results.

Advancing a step, the local units might pursue corrective action by more formal intergovernmental agreement. As a minimum, this might take the form of agreement among the several governments to take parallel action looking to pollution control. Such inter-governmental agreement might find expression in establishment of a basinwide council of governments. The council device, which has become increasingly popular during the last few years, offers local governments an organism through which they may cooperate on a voluntary basis without surrender of their traditional autonomy. It must be stressed that a council of governments is not itself a government, that it has no authority or power other than that granted voluntarily by the participating governments, and that it has therefore little coercive power over its member units. It has, for example, no power to lay taxes, or to issue directives (or take other action) with the sanctional force of law behind them.

Still, councils of governments in some areas have gained considerable influence through exercise of vigorous leadership over extended periods, and the council movement undoubtedly has gained in vitality in the last few years. This is true partly because they have been given encouragement by some states and by the federal government; the latter has, indeed, designated the council of governments as one kind of local agency qualified to receive federal planning funds. Even so, it is to be doubted that a council of governments would prove effective in controlling pollution throughout a river basin. It would seem that the most that could be hoped would be that such a council would make an areawide plan for pollution abatement, relying on local governments (and local industries) to take the necessary steps to implement the plan--and on its ability to persuade local leaders to take such action.

As an alternative (or a supplement) to the council of governments device, action looking toward pollution control might be taken through contracts entered into by two or more concerned governments. Conceivably all 16 local governments might subscirbe to one general contract through which all would agree to take certain common specified steps designed to abate pollution in the river. A less ambitious arrangement, and one more likely of achievement, would occur if two or three governments should contract among themselves to take preventive or remedial action. A regional network of intergovernmental contracts might in time grow out of such individual and localized agreements. It is apparent that such a network, however broad its scope, would be likely to take form without regard for a regional plan, or indeed for regional needs in any large sense.

A further step along the road toward effective regional action might be taken through establishment of an areawide special district for pollution abatement and control. A special district may be defined as a local government possessed of limited and carefully enumerated powers. (Special districts in some states and for some purposes are sometimes called "authorities".) It may have powers to undertake several activities, or it may be restricted to discharge of one function; most special districts are single-purpose in nature. There are more than 21,000 special districts in the United States, as noted above, and these include units which deal with such environment-related matters as soil conservation, drainage, irrigation water conservation, flood control, water supply, and sewage disposal. Such districts, which represent the most effective means yet devised for squaring governmental jurisdiction with felt programmatic need, enjoy wide and growing popularity, as is evidenced by their rapid increase in number over the last quarter century. Why not a special district for pollution control with boundaries coincident with the affected area--in this case, a (small) river basin?

Creation of a special district would signify the intention to deal with our areawide pollution problem through regional action. Special districts must be authorized by state law, either a general act conveying authority to establish such districts in certain circumstances or a special act covering a particular case. In either event local initiative is normally required, to implement action in the first instance, to procure passage of a special law and then implement action under it in the second.

Failing positive local action in the face of recognized emergency conditions, the state may itself initiate action to establish a special district--or, indeed, another organizational form: a regional planning board, for example, to "jawbone" government to clean up the pollution. Such action by the state removes the issue from our area of concern, which is limited to consideration of the moves available to local governments themselves.

Contemplation of possible local alternative actions teturns us to consideration of the criteria of local government adequacy examined above. It is clear at once that no local unit possesses the geographic reach to cope with the problem of basinwide water pollution. To employ the verbiage introduced earlier, area and function are not congruent, hence no government passes the test of areal adequacy. Nor does any local unit possess the legal powers required for regional pollution control, nor has any had regional experience in planning and executing a regional program. The data introduced in laying out the problem do not warrant comment on local fiscal resources, though in view of the financial stringency everywhere felt (or claimed), it is highly doubtful that the region's public fiscal structure could realistically be expected to assume the cost of an active pollution control program.[4] Technical resources (engineers, chemists, public health people, and so on) might be expected to be more nearly adequate, though a regional program for pollution control would require talent and experience not normally found among local governments. That the governments of the valley generally are politically strong goes without saying, for local communities are everywhere extraordinarily hardy structures. The political strength of existing governments would, indeed, pose a major obstacle to achievement of a politically viable regional organization. Regional leadership, too, almost certainly will be found to be in short supply, precisely because of the political strength (which reflects, among other things, shrewd leadership) of existing local governments.

The issue may now be joined forthrightly. What is required for solution (or melioration) of the problem is regional action, what is at hand is fragmented local government--government which, however successful it may be (or through long familiarity may seem) in meeting the felt needs of the individual communities, has, and by tradition has had, little interest in broader concerns. The local governments lack the kinds of strengths required for regional action. They also lack the leadership to identify extraterritorial (that is, regional) problems, plan programs for their resolution, rally public support, and devise arrangements for intergovernmental action--or for a new regional organization--to launch and execute an effective program of regional pollution control.

For their part, the people are not accustomed to thinking in areawide terms. The ecological region, be it associated with a drainage basin or otherwise defined, though a natural region to the environmentalist, appears utterly artificial to the local populace. The citizen is familiar only with that part of the stream which flows past his door, or at the most with that part in which he is accustomed to fish, boat, and bathe. He may know when the water supply is not pure, particularly if he can smell the impurity, but he is not likely to connect this with anything that happens upstream. As for pollution downstream, his community has always disposed of its wastes by dumping them in the river; what has happened to necessitate any change in that time-honored practice? It may be said that the people of New York know that the Hudson River is polluted, and the people of Trenton the Delaware; but do they in fact know this? And if they do, are they willing to support their local governments in the action programs necessary to bring the population under control?[5] But the argument wanders from its proper course, for our problem area is a small watershed with a limited population, where conditions have not yet deteriorated to a point comparable with those characterizing the Hudson or the Delaware.

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[4] The facts (a) that "outside" funds (federal and sometimes state) are available to supplement local funds for construction of pollution control facilities and (b) that operation of such facilities can be financed largely by user charges render the claims of local poverty in this context somewhat less than compelling. A further modifying consideration is a plan recently proposed whereby polluters would be forced to pay for the privilege of discharging pollutants into a stream. (The principal purpose of this charge would be regulation of polluters and control of pollution.) It can be persuasively argued that the commodity in short supply actually is vision and imagination, and of course will, rather than money.

The problem of regional leadership, or the absence thereof, is worthy of further comment. Such leadership, if it is to result in positive governmental action, must be of a political nature. All the lecturing done by professors and all the editorializing by newspapers which profess a valleywide vision will avail little except in terms of background education. What is required and what must be had for regional action is regional political leadership, and this is one of the rarest of all commodities. As the author has observed elsewhere, there is no regional courthouse or city hall, no regional high school with its regional football team and its regional drum majorettes to stir regional hearts, no valleywide fair. There may be institutions having social and economic impact over a wide area, but they are not paralleled by effective political organizations of equally wide scope. There is, then, no areawide electorate, there are no regional offices to fill, there is no basinwide political organization for the aspiring leader to ite to. His concerns are and normally must remain rooted in the local units: in the case of our problem area, the three counties, three cities, and 10 villages comprising the regional fabric of local government.

It must be concluded that local government offers little hope for effective action respecting problems of regional scope. This generalization applies specifically and particularly to pollution control in any stream, however small and however limited its watershed, which flows through two or more local jurisdictions. These are contributions which local governments can make toward the preservation and restoration of the environment, but their number and significance are comparatively limited. Those who seek action to bring the environment under effective management would do well to look elsewhere than to local government. The states must take the initiative, in full partnership with the federal government, if anything of major significance is to happen.

Given positive interest and concern on the part of the state, it may be possible to bring about regional action despite local indifference, and even hostility. We have noted that the state is the source of all

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[5] Pollution in the Delaware River has been materially reduced in recent years, largely through the work of the Delaware River Basin Commission. That agency, however, is a state-federal rather than a local government instrument.